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Energy in Society

A Resource Guide for Teachers

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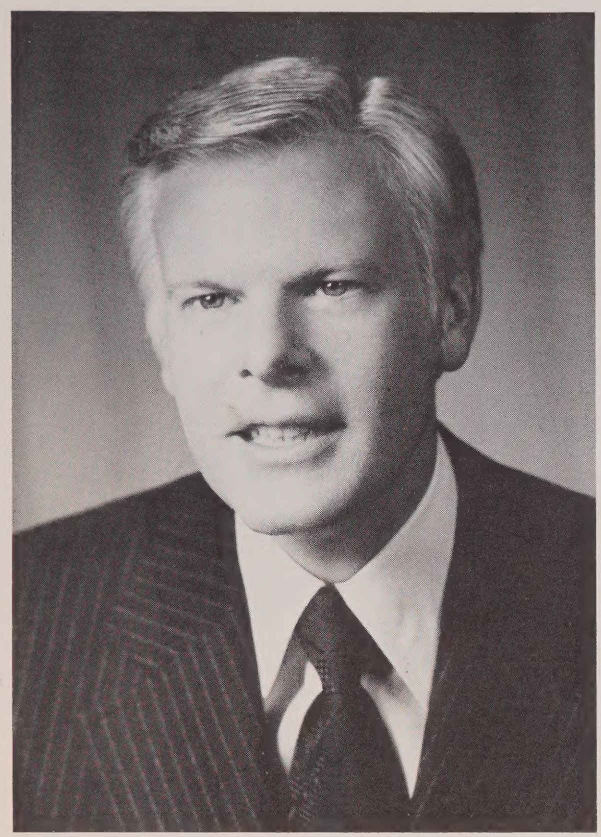
The Conservation of Energy



This booklet is about the energy crisis.

It is also about informed decisions.

The energy crisis is almost certain to be a persistent and critical factor in our lives in the future. It will affect many decisions, from doing the laundry to establishing a new industry. It will affect virtually every facet of life. This booklet is intended to help teachers in every discipline to bring the energy crisis into the classroom in a constructive way – not as a scare tactic, but as a fact of life which must be faced.

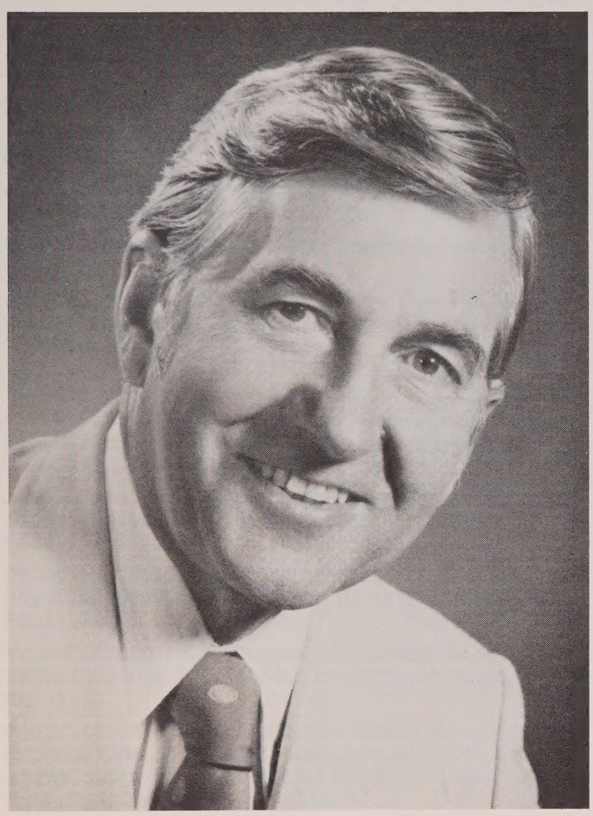
It is imperative that our young people learn to make informed decisions about the use of energy in their lives. As a starting point, students must learn about energy in all its aspects. Equipped with such knowledge, they should begin to consider related values, the lifestyle they desire, and the lifestyle that is possible.

Students in our schools today, and those who will follow in future years, will have to make decisions about energy and then live with the consequences of those decisions. The world of the future will be shaped by those decisions. I sincerely hope that they will be able to say that Ontario schools prepared them well for their responsibilities.

Thomas L. Wells

Hon. Thomas L. Wells
Minister of Education

Why Conserve Energy?



For almost a century young people have grown up in Ontario with the expectation of abundant power at their fingertips. But we have now harnessed most of our big waterfalls to produce electricity. The great deposits of oil and gas that have powered our cars and heated our homes are running out. Our available supplies of coal are limited.

Scientists and engineers are seeking to develop other energy sources – ways to harness the energy of the sun, the tides, and the wind. Energy from such renewable sources will undoubtedly be commonplace within the lifetime of the young people in Ontario schools today. But until these new sources of energy are harnessed for our use, we must conserve the energy sources we now have in limited supply.

It is difficult to change lifetime habits. Those of us who have grown up to expect to always find light, heat, and power at the flick of a switch and gas for sale at the service-station pump cannot imagine otherwise. Yet someday soon we may flick a switch and find that nothing has happened or we may find that our use of automobiles is becoming more and more restricted.

This is extremely likely to happen over the next few years unless we very seriously conserve available energy. We must understand and appreciate this increasing energy shortage ourselves so that we can clearly and honestly inform the young people of Ontario. We must help them develop a true appreciation of the fact that our energy supplies are not limitless. We must make them clearly aware of what will happen if there is not sufficient power to run factories, to heat homes, or to move vehicles.

That is why this booklet has been prepared by the Ministries of Education and Energy. I sincerely hope that teachers in every field of study will utilize this material at every opportunity to make the young people of this province aware of how they can avoid wasting energy and of the consequences if they do not practise energy conservation.

Reuben Baetz

Hon. Reuben Baetz
Minister of Energy

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"The Hydrologic Cycle" (extract, p. 36): adapted from *The Water Story,* p. 6.

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Credits

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Part 1, Introduction

Table of Contents

Introduction 2

Goals and Objectives 3

1. Energy and Systems 5
2. A Definition of "System" 5
3. Energy and the Global System 12
4. Canadian Energy 14
5. Energy and Our Home Systems 18
6. Forcing Functions and Constraints 19
7. Slowing Down the System 23
8. Appendix: Energy and Power 26
9. Bibliography 30

★ A star beside the text indicates an investigative activity for students.

Introduction

This resource guide has been prepared to give teachers some ideas by which they may help students in the Intermediate and Senior divisions develop an energy-conservation ethic. The suggestions in this guide cut across subject boundaries: the energy shortage is likely to affect all aspects of life, and it is hoped that teachers in every discipline will help students see its implications.

Most students in the age group for which the activities of this guide were designed acquired their present energy-consumption habits during a time when fossil fuels and hydro-electric power were inexpensive and seemingly inexhaustible. Like their elders, they have acquired a dependence on the conveniences, comfort, and speed that an unrestricted use of energy offers. *All* of us need to be encouraged to develop a tendency to conserve – a tendency that must be stronger than our present tendency to consume.

For a billion years the earth's annual energy balance sheet was a little on the plus side with small amounts of energy being laid away. Each day the sun shone, and plants built energy-rich molecules – more than enough for their own growth and survival into future generations. Much of the remainder was eaten by herbivores, which in turn were eaten by carnivores; everything that died furnished food for scavengers and a host of decomposers. There was a surplus of food. Some of it, buried in mud or at the ocean bottom or otherwise protected from decomposition, became available recently when modern man found it as fossil fuels.

If the use of the past tense in the last paragraph appears unduly pessimistic, consider the following figures. In a primitive state, man probably used about 6 GJ of energy per year. In many parts of the world, people still use about this amount of energy. In Canada, however, energy consumption is now approximately 400 GJ per person, a quantity exceeded only by the United States. Many other "developed" countries are almost as profligate. We are using energy at a rate more than sixty-five times that of man in the natural state. In these circumstances, it is hardly surprising that the world's bank of fossil fuels, saved over eons of time, is now nearing depletion.

In the light of this situation, this sourcebook of activities and problems has a place in most of the existing courses in the curriculum. Teachers will notice that there is a strong emphasis on the students' own homes in the activities outlined on the following pages. This emphasis is intentional. It is in the home that substantial savings of energy can be made (other areas are probably outside the scope of the students' influence), and it is in the home that values are established and habits reinforced. Attitudes and values must be deeply ingrained if they are to make any appreciable impact on the energy shortage.

Teachers should select activities that fit the interests of their students and the aims of the program; they should arrange these activities in a sequence that is logical and productive.

Although the energy-shortage theme can fit into all disciplines, two particularly relevant areas are science and values. It is hoped that a study of the energy shortage in the context of science will give students a basis of fact on which to act and help them to understand the reasons for the crisis they face and to devise ways to live with it.

The study of values will help students think through the adjustments they must make in the years ahead so that they will choose an environmentally sound life style, rather than the one that appears to be the easiest. It is important for values studies to follow the implications of any decisions made to their logical conclusions, particularly in the areas of life styles and personal freedom. Students should be permitted to clarify their own values for they will not have teachers to guide them outside the classroom. It is only those who have learned to think and to weigh the consequences who can be trusted with our future.

Goals and Objectives

The ultimate goal of all activities in the sphere of energy conservation is the establishment of a new life style, one that depends less on fossil fuels. This goal reaches every corner of an individual's life and will exert an influence on society far into the future.

With such a broad goal in mind, teachers will probably rely on both extrinsic and intrinsic motivation: certainly both have a place. It is wise to emphasize the saving the individual can realize from conserving fuel. Insulating a house, for example, usually saves enough in the cost of fuel over a five-year period to repay the initial cost. Other savings are equally attractive. More than external rewards are needed, however, to reverse a deeply ingrained way of life. For this, teachers must encourage attitudes of responsibility and sensitivity to the needs of others. Intrinsic motivation is more difficult to establish, but valid solutions to most of our energy problems will be motivated by sound and enduring values.

To fulfil the broad goal of energy studies, a number of more immediate objectives must be achieved. In this part, these objectives are divided into five categories:

1. *Values study.* Students should be helped to adopt a values system that reconciles the integrity of the individual and the priorities of society. In this process, students should become sensitive to the use of energy, whether by themselves or by society; they should recognize that energy-conservation issues, like most others, are complex and many-faceted; they should accept the need to conserve energy resources.

One way to explore the values that are part of all energy studies would be to use a case study, such as the one outlined in the next section. Teachers should note that this particular situation is only used as an example; it is possible to choose an incident in most schools in which all or some of the students have been involved or possibly an incident that has been reported fully in the news media.

2. *Problem-solving.* Students must develop a scientific approach to problem-solving – making and recording observations, formulating and testing hypotheses, moving from the particular to the general, and accepting conclusions only when they are supported by evidence.

3. *Skills.* Through energy-conservation education, students should acquire the following skills: collecting and organizing information; measuring; reporting facts with lucid, well-organized sentences and paragraphs or through pictures and graphs; using the techniques of one or more of the arts to express personal thoughts and emotions in a satisfying way; working with others in pursuit of a common objective.

4. *Knowledge.* Students must know the facts about energy and understand the concepts and principles connected with it.

Many basic issues involving Canadian self-sufficiency in energy supply will be decided in the next two decades. These decisions must be made by an aware and energy-literate citizenry. The educational community has a major responsibility.

> It seems to me that the most important political questions facing Canada for the balance of this century – certainly for the next decade – are questions that relate to energy policy in one way or the other, and they involve a lot of quite technical questions. It seems to me that if one is to have a democracy that is more than just a catchword, all or at least a lot of the people will be involved in making decisions related to very important issues; that seems to be the definition of democracy. If we can't communicate this kind of information to a very wide audience, then they simply will not be involved in those decisions. Energy information is usually put in a form which is intelligible to experts, and somehow we have to gear it down to a point where most people can understand it; obviously it is in the school system where we will have the largest audience.
>
> Adapted from Robert Paehlke, "Energy Supply and Demand in Canada", Man-Environment Impact Conference, Toronto, November 1976.

5. *Overt action.* The purpose of this resource guide will be partly served if its use results in a saving of energy by teachers and students either individually or collectively. It is hoped that the energy invested in the writing and production of these pages will be balanced by an immediate saving of energy in Ontario classrooms and beyond.

To achieve these objectives, it is hoped that teachers will undertake suitable activities such as the ones in this resource guide. These activities are organized around four themes: space heating, electricity, water and food. Underlying all the activities is the concept that a new life style is needed, one requiring more effort from the individual with less reliance on fossil fuels. This resource guide attempts, then, to establish new energy-conserving patterns of behaviour.

The activities suggest ways in which teachers can make understandable the rather technical language of energy literature. We feel that an understanding of energy flow in terms of systems is the proper pedagogical base for understanding energy issues. Consequently, this introductory section considers the concept of a system in terms that students will grasp. Students should be led to see energy issues in terms of complete systems and the values that influence the rate of system flow. Ultimately, they may go beyond this and appreciate energy issues in terms of the interaction of many systems.

Values

The study of values can form the focus of a unit in almost any subject area. In fact, values usually become clearer when they are discussed in the context of a particular area of human endeavour – transportation, perhaps, or a unit in urban studies. It should be understood, therefore, that the following suggestions can be applied to almost any subject in which students are engaged.

An exercise on values will obviously gain effectiveness if students are deeply concerned about the energy shortage to begin with. Science courses in the school may have already given them a basis of fact on which to reason; or, teachers may want to begin in the way suggested here.

★ Newspaper clippings provide a good starting point for an investigation into the energy shortage. Since the most cursory examination of news sources will reveal dramatically opposing viewpoints, this activity will, as a by-product, provide an exercise in checking accuracy and bias. A class might, for example, keep a loose-leaf notebook of clippings, with a section for each viewpoint and, for that matter, for each facet of the problem. One section might deal with oil, one with statements by leaders of different political parties, one with statements of oil company executives, and so on. The newspaper clippings will probably suggest other headings as well. Students could then check the background of news stories through research in the library, examination of old copies of Hansard, and interviews with local figures who might be expected to have expert knowledge. In some areas, it is possible to peruse old newspaper files; in others, this source is not available to those not actually employed by the newspaper.

In view of the energy shortage, students should work out which uses of energy are important and which they can do without. Because of the importance of this particular question, the matter of government controls is almost sure to arise. At least some students will say that for the sake of the greatest good for the greatest number, *everyone* should be forced to save energy *by law*. Others will object to excessive controls. Most students will be able to see that a certain amount of control is necessary for protection: otherwise, so much time would be spent protecting one's person and property that there would be no time for any other activity. On the other hand, controls can become so overwhelming that the life style they were designed to protect is not worth saving. Most people spend a large part of their lives debating just where the dividing line comes between these two extremes.

In keeping with the principle that students should be personally involved, the values-study unit should encourage each student to give up one thing – an object or an activity – that entails a high use of energy. Students could choose their own sacrifice, and could perhaps prepare a paper showing the effects of their choice on themselves, their life style, and on other people.

Obviously, whatever is given up would have to be in frequent use; a student who habitually stayed at home would not accomplish anything by refraining from taking airplane trips to the south seas. For this student, giving up television-viewing for a couple of hours a day would be more effective. A case study similar to the following is yet another means of focusing on energy in the context of values study:

Case Study
The loss of heat occasioned by an open door to an outside smoking area was a matter of concern to the head of the science department, Ms. Jill Wise. Ms. Wise had organized a highly successful campaign to save energy. Among student suggestions that had been acted on were:

1. a reduction in temperature so that the last monthly heating bill had been 8.9% lower than the corresponding month the previous year (the saving of over $300 had been put in the student council's funds);

2. removal of about half the fluorescent light bulbs in the school resulting in an unestimated saving.

Ms. Wise felt that the heat lost because of the frequently opened door amounted to as much as the saving that resulted from lowering the thermostats in the school. She had no figures to support this belief and did not claim to have.

Some students felt strongly about maintaining their smoking area, which they had obtained after complicated negotiations through the student council and the school board. When the principal, Ben Strong, ruled that the door would stay closed at all times, these students felt that their personal freedom was endangered.

Two students who reacted to the closed-door announcement were Dan Crooks and Stan Payne. They may or may not have been striking a blow for individual freedom – one interpretation was that they never listened to announcements anyway. Within minutes of the principal's announcement over the loud-speaker system Dan and Stan went through the controversial door to smoke a cigarette. Ms. Wise warned them of the consequences at the time, but in the afternoon when they did the same thing again, she took them to the principal's office and they were suspended. The two boys told their friends that their suspension was a result of the removal of smoking privileges.

The controversy now erupted into a demonstration with placard-carrying students parading on the school grounds. The protest was reported (with pictures) in the local newspaper. Principal and teachers refused comment in the local press.

In dealing with a case study like this, it is wise to begin by defining the issues. There are a number here, as in any other worth-while controversy.

★ Once the issues are defined, students can make a values continuum for each participant. In a continuum for Ms. Wise, for example, one end of the line would represent complete support of her position, the other complete disagreement. Students would all place X's on the line to indicate the measure of their agreement with her. Those who considered her half right and half wrong would place their X's right in the middle of the line; others would place their X's at varying distances to the right or left, depending on their opinions. If there is a continuum for each participant, considerable variation in viewpoint will be revealed. Students could defend their opinions orally or in writing. They should be free to express their own views, with the teacher acting as a moderator, keeping discussion on the subject and within the bounds of logic, and occasionally asking questions.

★ In another approach to the case study, students would role-play the parts of the participants in the drama. They might decide that the board of education had set up a tribunal to judge the issue. In this kind of drama, there would be speaking parts for many members of the class. Those left over could be board members and could have the power to ask questions as the participants stated their cases.

It is hoped that, through these activities, students will reach the conclusion that:

1. Different opinions on issues may be the result of different basic assumptions. The students are concerned about personal freedom, the administration about the overall functioning of the school.

2. Some arguments are not valid, others are. An invalid argument doesn't necessarily demolish the point of view, but it does undermine its acceptance by others.

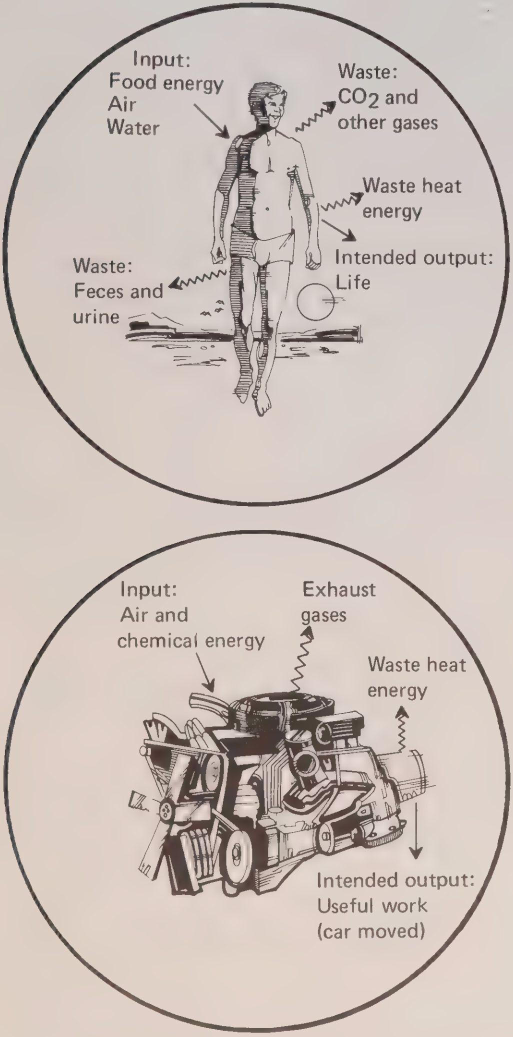
A criterion for the use of an activity from this guide, or from other sources, should be its potential for assisting students to clarify their energy-related values. Values-education techniques, appropriately selected and applied, will contribute to the realization of this potential.

1. Energy and Systems

The body can be compared to a machine such as the automobile engine. The engine takes in (input) an energy-rich material (gasoline), transforms the energy into low-grade heat energy and other wastes, and moves the car from place to place (intended output) in the process (see figure 1.1).

Figure 1.1

A Comparison of Two Energy Systems



Our body cells provide life-sustaining energy. Within the cells energy-rich food molecules are broken down (catabolism) releasing energy to power the growth, repair, and maintenance of cells (anabolism) and other activities characteristic of life. Most of the energy is ultimately released through the skin or eliminated with body wastes. The body is an energy-consuming system: it takes in high-grade energy-rich materials and transforms them into the forms of energy which the body can use, ultimately releasing all as waste heat. Without this continual conversion of energy, life (the intended output) could not be maintained.

2. A Definition of "System"

> It is essential that we view the whole matter in a systematic way, that is in terms of systems.
>
> From Garret Hardin, "Carrying Capacity of the Earth: The Central Ethical Concept", Man-Environment Impact Conference, Toronto, November 1976.

The term "system" is used frequently in conservation literature. It is important that students understand this concept. As used in this document, *a system is a group of interdependent components having an arbitrary boundary which is established as a means of reference.* A system has a purpose – that of receiving input and transforming it to an intended output. Energy makes the system go. In the process at least one by-product, usually considered as a waste, is always produced. The following example is used to illustrate the way in which we employ the term.

We may consider the human body as a group of systems, such as digestive, reproductive, and skeletal systems. Each system comprises a group of interdependent components contained in an arbitrary boundary, since in reality all body systems are interrelated and interdependent. It is, therefore, a conceptual convenience for us to consider the way in which food is digested in terms of a discrete system. It gives us a means of reference and a unit of body structure of manageable size. However, when we talk about the digestive system, we realize that it is part of something larger and that outside factors affect it. We know that it cannot survive alone.

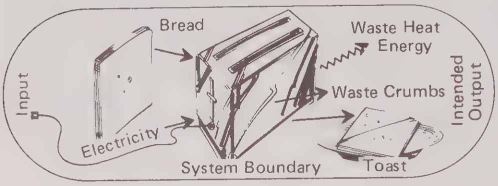
There are advantages to grouping components of a complex structure into a system. The major components can be identified on the basis of a common function and their interdependency in performing it. For example, the components of the digestive system include the mouth, the esophagus, the stomach, and the intestines. We know that various relationships exist among these components. In order to understand their interaction, we will seek out all other components – teeth, tongue, orifices, duodenum, and so on. Such a system offers a framework by which a more detailed accounting of the major and minor parts may be made. From this framework may come a greater appreciation of how the components function individually and collectively as they transform the ingested food (input) into a form (output) that can be absorbed into the blood stream. The output of one system often provides input for another – in this example, the digested food is absorbed into the circulatory system.

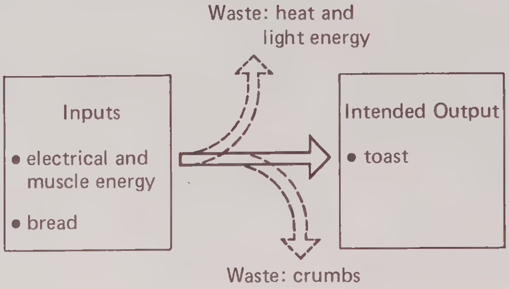
There is nothing permanent or sacred about the boundary of any system. It can be expanded or shrunk according to a person's perceptive ability. For most people it is convenient to consider the body as an organization of systems. However, a professor of anatomy could move the boundary outward and conceptualize the whole human body as a system.

Apprentice automobile mechanics find it best to start by studying specialized systems: the power-train system, the braking system, the cooling system, and the electrical system. They learn automobile repair by becoming acquainted with the components of each system and its boundary and how the components within this boundary are interrelated. When they become master mechanics, they will be able to move the boundary outward (like the professor of anatomy) and understand the automobile in its entirety, as a single system.

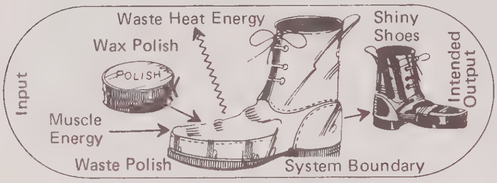
Figure 1.2

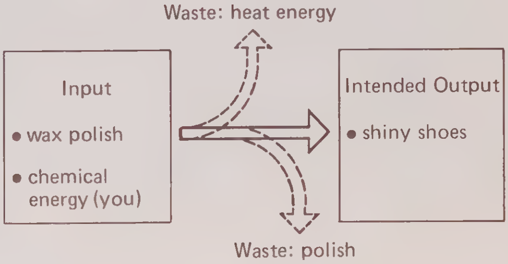
1. *The Toasting Bread System*
Components: bread, electrical energy, chemical energy (you), and the toaster



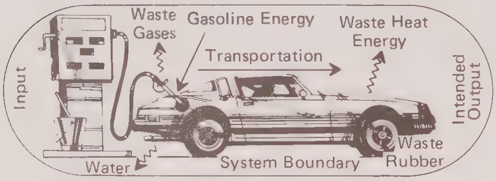


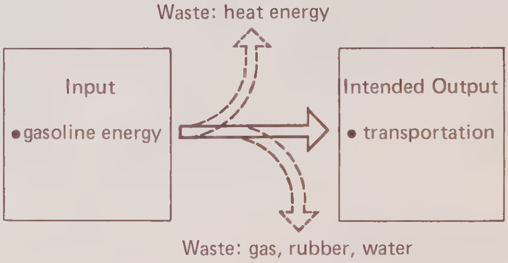
2. *The Shining Shoes System*
Components: wax polish, cloth, chemical energy (you), and shoes



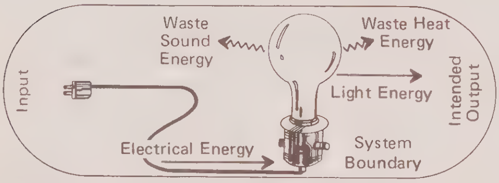


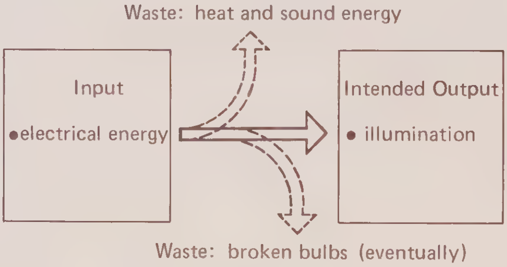
3. *The Automobile Transportation System*
Components: chemical energy (gasoline) and the automobile



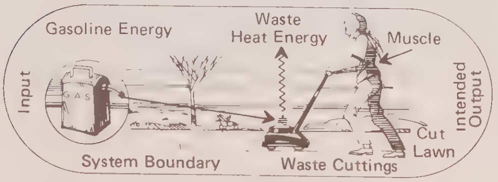


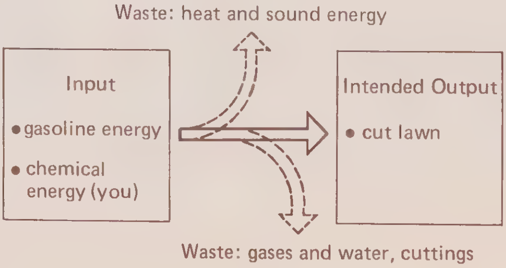
4. *The Electric Light Bulb System*
Components: electrical energy and the light bulb




Waste: heat and sound energy
Input
• electrical energy
Intended Output
• illumination
Waste: broken bulbs (eventually)

5. *The Lawn Cutting System*
Components: chemical energy, (gasoline) chemical energy (you), lawnmower, and grass





We have defined a system as a group of interdependent components having an arbitrary boundary which is established as a means of reference. In the pages that follow, we are primarily interested in the energy conversions that occur in a system; that is, in what makes the system go and in what it costs in energy to make it go. Consider the examples of energy conversions in figure 1.2. The boundary and components of each system have been identified.

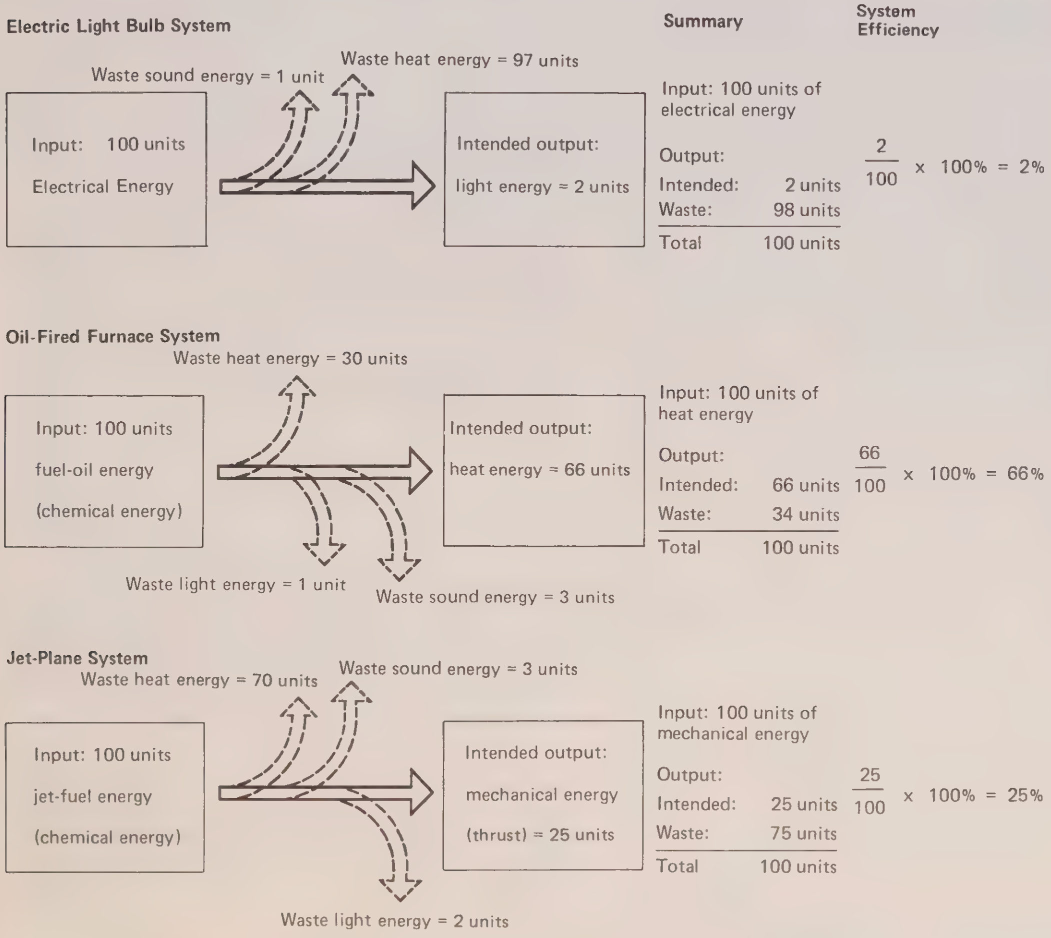
★Through reference to the sketches in figure 1.2 or to other systems that you and your students might design, develop an understanding of the term "system". With each example, you might consider the value of the intended output when examined in the light of our need to use less energy. Should we toast one piece of bread in a two-slice toaster? Should we toast bread at all? When is transportation by car valid? To take the family for a drive? To take a 45 kg woman two blocks in order to purchase a package of cigarettes? How might we slow down the energy consumption in each system? Which system produces by-products (wastes) that can be used again?

★In each example in figure 1.3, the intended output ultimately is converted into waste heat energy. The light and sound energy are absorbed by the environment and so converted to waste heat energy. The space-heat energy escapes from the house structures and enters the surrounding environment as waste heat energy. The heat energy of the jet's gases and the accompanying sound and light energy ultimately dissipate as low-grade heat into the atmosphere. Thus, in each case, our high-grade energy supplies end up being converted to waste heat. The value we place on the intended output helps us decide whether the energy conversion is good, wise, or otherwise.

From the examples in figures 1.2 and 1.3, several concepts may be developed at an elementary level: (a) the concept of system efficiency, and (b) the first and second laws of thermodynamics.

Figure 1.3

Efficiency of Energy Use



Input: 100 units of electrical energy

Output:		
Intended:	2 units	$\frac{2}{100} \times 100\% = 2\%$
Waste:	98 units	
Total	100 units	

Input: 100 units of heat energy

Output:		
Intended:	66 units	$\frac{66}{100} \times 100\% = 66\%$
Waste:	34 units	
Total	100 units	

Input: 100 units of mechanical energy

Output:		
Intended:	25 units	$\frac{25}{100} \times 100\% = 25\%$
Waste:	75 units	
Total	100 units	

System Efficiency

As we saw in the illustrations above, energy is wasted when it is converted from one form to another. Wasting energy can mean one of two things. First, energy is wasted when it is released to the atmosphere – when, for example, a pleasant recreation-room log fire throws most of its heat straight up the chimney. Or, second, energy can be converted into an unnecessary and unwanted form. This happens in a rather extreme way in an ordinary light bulb, which converts only 2% of the electrical energy fed into it into light; the other 98% is wasted as heat.

★ Consider each item in table 1.1 as a system. What is the intended output of each item? Give two ways in which you might use the intended output. An example of this could be the space heat produced by a home oil furnace. One use is to heat your living room, another is to heat an unused bedroom. Is the energy conversion for each use good or wise? For every 100 energy units of input, how many are converted into the intended output? What are the likely forms of the waste energy in each system? What happens ultimately to all the energy put into the system? Which items use renewable energy sources such as the sun and wind?

★ Criticize the following statements:

1. Electric heaters use energy the most efficiently of all, so we should all convert our furnaces to electricity. Electric heaters are cleaner, too, so we'd cut down on pollution if everyone used electric heat.

2. Since silicon solar cells are only 12% efficient, they are too wasteful. We should not use them.

Table 1.1

Table of Efficiencies

Maximum Efficiencies for Devices in Good Condition			
Electric heater	99%	Airplane engine (jet)	25%
Hydro-electric generator	95%	Fluorescent lamp	20%
Electric motor, large	92%	Silicon solar cell	12%
Dry battery	90%	Steam locomotive	9%
Home gas furnace	85%	Incandescent lamp	2%
Car battery	73%*	Electrical generator:	
Home oil furnace	66%	oil or gas boiler	88%
Wind generator	60%	steam turbine	45%
Diesel engine	36%	overall efficiency	40%
Car engine	26%		

*each complete charge-discharge cycle

★ Calculate the efficiency of the following systems which contain within their boundaries two or more of the items listed in the table above:

Example:
An oil-fired steam-turbine power station generates electricity which is used to drive a large motor.

Solution:
The system efficiency is

$$\frac{40}{100} \times \frac{92}{100} = 36.8 = 37\%$$

1. An Ontario Hydro generator at Niagara Falls is used to generate electricity, which then drives a large electric motor.

2. A car battery is charged during the day by means of a silicon solar cell. At night, the battery is used to power an incandescent lamp.

3. A diesel engine powers a generator similar in design to a hydro-electric generator. The electricity generated is used to run fluorescent lamps.

The Laws of Thermodynamics

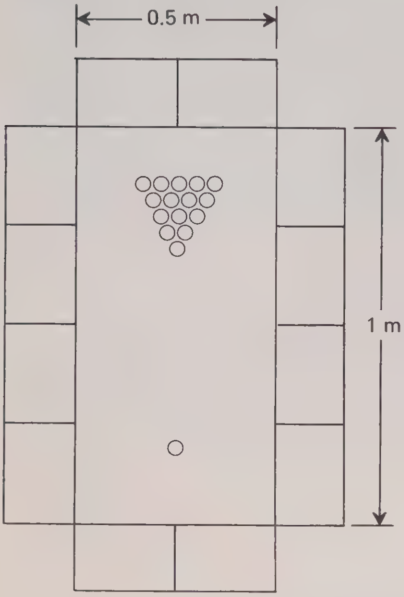
Two basic laws are evident in the examples. The first law of thermodynamics is formally called the "law of conservation of energy"; that is, energy can neither be created nor destroyed. The important point for students to grasp is that this refers to the *total* energy. In the above systems, the energy takes on different forms, but in each case the total of the energy transformed (waste + intended output) remains constant. In each case, 100 energy units enter the system and the total after the energy has been transformed (when you add all the converted forms) equals 100 units.

The second law is a more difficult concept, but every bit as important as the first. It specifies the direction in which physical processes move. For example, imagine that your stove oven is fully heated. The air in the oven is then much hotter than the air in the kitchen: there is a concentration of heat energy in the oven. You turn off the oven switch and open the oven door. The heat energy in the oven (hot air) moves out into the cooler air of the kitchen. The concentration of heat energy in the stove disperses, *moving* into the cooler air of the kitchen.

The second law states that in spontaneous processes the heat flowing between two objects (oven and room in this case) moves from the hotter to the colder (you will never get a warm behind by sitting on a cold rock); that concentrations of things tend to disperse; that structure tends to disappear; and that order becomes disorder. For example, if you add a drop of ink to a glass of water, the ink disperses in the water. There is little probability that the opposite will occur, that is that the dispersed ink will ever become a concentrated drop of ink in the middle of the glass. Furthermore, considerable work and a great expenditure of energy would be required to make each particle of ink return to the drop of ink. Another such example is the dissolving of a sugar cube in a glass of water.

★ This aspect of the second law of thermodynamics may be illustrated through the following activity: we will call it "marble pool". It requires sixteen marbles per group of four or five students. Using books, have each group fence off a pool table, 0.5 m by 1 m.

Figure 1.4



★ Set up the marble "billiard balls" as illustrated. Have the groups compete against each other on the following basis. One member, chosen by the group, will fire the remaining marble at the cluster of fifteen, using a pencil as the cue. If the group is not satisfied with the way the marbles have been dispersed on the first shot, it is allowed one more shot. *After* the group has dispersed the marbles, announce the rules. The competition will last exactly five minutes (more time can be given, if desired). The objective is to return the dispersed marbles as close to their original pattern as possible. Each member of each group will in turn take a shot with the cue. Each group can take as many shots or go through as many rounds as it wishes in the time allowed. Any marble can be fired with any shot, using only the pencil cue. Keep count of the number of shots taken. The winner will be the group that returns the marbles, in the time allowed, closest to the original pattern.

Discussion: Initially, the marbles were ordered and concentrated together. The first shot dispersed them. To return them to their original pattern will require many shots (perhaps an impossible number). The number of shots suggests that much more energy is needed to return them to an ordered arrangement than was needed to disperse them. The initial concentration of marbles can be compared to the initial concentration of heat energy in the oven, or of the ink in the drop, or of energy in a litre of gasoline. Once dispersed, it takes much more energy to return it to its original form than it took to disperse it.

> Another, and for our purposes more pertinent, perspective on the second law of thermodynamics comes from relating disorder to the degradation of energy. Order, it seems, is related to the ability of energy to do work, and while the first law insists that the total amount of energy in the universe remains constant, the second law requires that the fraction of energy available to be used is continually being diminished. For this reason it is often said that the second law tells us that the universe is *running down.* This idea can be understood from the fact that energy is most usable where it is most concentrated – for example, in highly structured chemical bonds (gasoline, sugar) or at high temperatures (steam, incoming sunlight). Since the second law says that the over-all tendency in all processes is away from concentration, away from high temperature, it is saying that, over-all more, and more energy is becoming less and less usable. Typically, the manifestation of this degradation of energy is the production of heat at relatively low, hence relatively useless, temperatures – for example the heat of a car's exhaust, the heat of tire friction against the road, the heat radiated by your body, the heat of a decomposing animal carcass.
>
> From Paul R. Ehrlich and Anne H. Ehrlich, *Population, Resources, Environment: Issues in Human Ecology,* 2d ed. (San Francisco: W. H. Freeman and Company, 1972), p. 55.

To clarify this quotation, consider the following energy conversions, which occur in the manufacture of chocolate bars.

Some Energy Conversions Occurring in a Chocolate-Bar Manufacturing System

The cocoa tree thrives in rich solar energy latitudes close to the equator. Here solar energy powers photosynthesis and the formation of the cocoa bean. Most of the sunlight is converted to waste heat energy and enters the earth's atmosphere. Native workers gather the pods, cut them open, remove the beans, and carry them to trucks. Waste heat energy from the workers' bodies enters the earth's atmosphere. The beans are transported by truck to a boat. Gasoline is converted in the process to waste heat energy and enters the earth's atmosphere. The boat transports the beans to Montreal. Diesel oil is converted to waste heat energy, which enters the earth's atmosphere. In each of the remaining operations, energy is also converted to waste heat energy and enters the earth's atmosphere. The beans are transferred to trains and transported to the factory. The beans are unloaded and moved into the factory where they are sorted into blends. The beans are roasted at temperatures exceeding 204°C while being turned in revolving drums. The fragments are milled to a smaller size, releasing cocoa butter in the form of a free-flowing liquor. The chocolate liquor is added to a paste of sugar and milk and most of the moisture is evaporated. Cocoa butter is added and grinding takes place. Rollers then rub the chocolate repeatedly across corrugated granite bases, then it is moulded into bars. The bars are wrapped and packaged and then transported by trucks to stores.

★ Students may be asked questions such as the following:

1. What are the various forms of energy converted in this manufacturing system?

2. Which of these have great potential for doing work; that is, in which ones is the potential energy most concentrated?

3. Explain how the first law of thermodynamics is satisfied in terms of energy conversions.

4. By referring to the manufacturing process, explain how the total supply of energy available for use in the world has been diminished.

5. In terms of a chocolate bar that you have eaten at least a week ago, explain how you have contributed to the degradation of energy.

A basic concept to be developed from a discussion of the manufacturing process is that all forms of energy are gradually converted into heat energy and become so dissipated into the environment that people can no longer make use of them for their purposes. Students should be led to appreciate that all manufacturing systems degrade energy from a well-ordered, concentrated form to disordered heat energy, which is usually immediately dissipated into the earth's atmosphere and lost to us forever.

Heat Energy and Climate

Consider all the waste heat energy produced in the production process described above. Multiply it by all the production processes which are operating in the world and you will appreciate the situation described here.

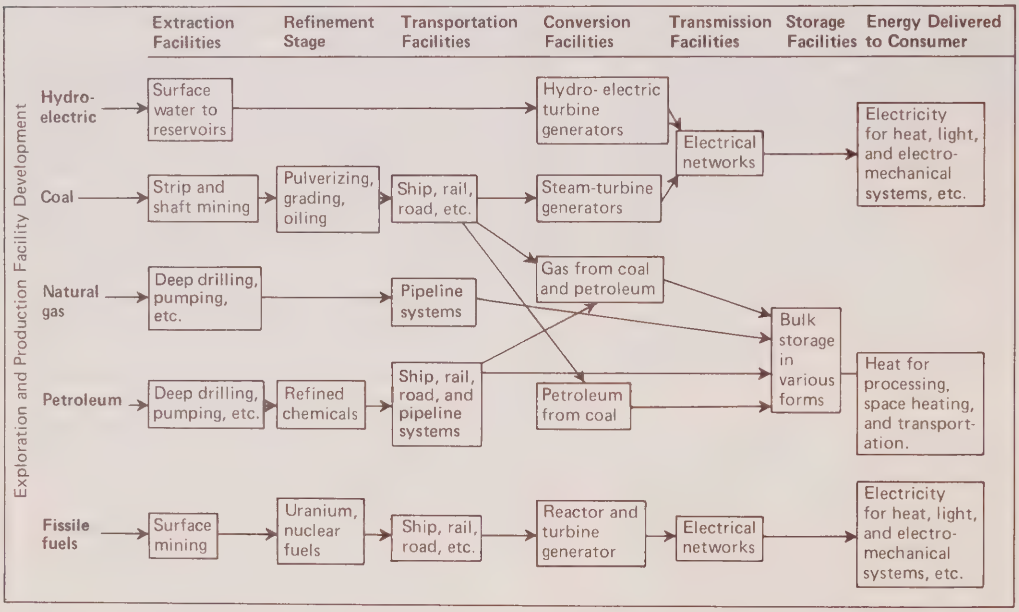
> One of the least understood, but potentially most damaging effects of energy on the environment is in the area of climate. World climatic patterns depend on the thermal balance of the earth-atmosphere system, determined largely by incoming solar radiation. This thermal balance can be altered by man, in allowing the emission of carbon dioxide and particulate pollutants into the atmosphere, affecting its absorption and reflection of radiation; in altering the nature of the earth's surface, and hence its reflectivity; and in dissipating energy in the form of heat into the system from its stored state in fossil or nuclear fuels. . . . It is important to remember that regional or global temperature changes will lead to changes in the patterns of all climatic parameters, including pressure systems and rainfall: such changes need not be catastrophic to cause immense dislocations in man's activities. Furthermore, changes may be self-reinforcing and irreversible.
>
> From Dr. G. Winstanley, "Energy Analysis", Office of Energy Conservation Research Report No. 6 (Ottawa: Department of Energy, Mines and Resources), p. 4.

Proven Energy Systems

Figure 1.5 shows the five major energy systems that deliver energy to the Canadian consumer. Using it, you can refer to energy systems, such as the petroleum-automobile system, the hydro-electric-toaster system, or the fossil-fuels – electric-heater system. Each reference traces energy from its source through the entire system. This extends the boundary of examples in figure 1.2 to include the entire system.

Figure 1.5

Proven Energy Systems


Extraction Facilities
Refinement Stage
Transportation Facilities
Conversion Facilities
Transmission Facilities
Storage Facilities
Energy Delivered to Consumer
Exploration and Production Facility Development
Hydro-electric
Surface water to reservoirs
Hydro-electric turbine generators
Electrical networks
Electricity for heat, light, and electro-mechanical systems, etc.
Coal
Strip and shaft mining
Pulverizing, grading, oiling
Ship, rail, road, etc.
Steam-turbine generators
Gas from coal and petroleum
Natural gas
Deep drilling, pumping, etc.
Pipeline systems
Bulk storage in various forms
Petroleum
Deep drilling, pumping, etc.
Refined chemicals
Ship, rail, road, and pipeline systems
Petroleum from coal
Heat for processing, space heating, and transportation.
Fissile fuels
Surface mining
Uranium, nuclear fuels
Ship, rail, road, etc.
Reactor and turbine generator
Electrical networks
Electricity for heat, light, and electro-mechanical systems, etc.

Source: Dr. G. MacEachern and B.W.D. Elliott, "Agriculture and the Energy Question", in the *Agrologist* 2, no. 6, November/December 1973.

Table 1.2

Energy-System Efficiency

	Efficiency of each step (in %)	Efficiency including all preceding steps (in %)
Production of crude petroleum	96	96
Refining of petroleum	87	83·5
Transportation of petroleum	97	81
Thermal efficiency of engine	29	23·5
Mechanical efficiency of engine	71	16·7
Rolling efficiency	30	5

Source: Gabel Medard et al, *Energy, Earth and Everyone: A Global Strategy for Spaceship Earth* (San Francisco: Straight Arrow Books, 1975), p. 141.

Energy-System Efficiency

Energy-system efficiency is a measure of the amount of useful work actually performed for an *entire* energy system. The intended output for the petroleum-automobile energy system is to have the automobile roll over a distance. Table 1.2 gives the efficiency of each step. Ninety-five per cent or more of the energy contained in the original amount of crude petroleum is used not to move the car along the road, but to extract and refine the crude oil; to carry the gasoline to the filling station; to heat the water in the radiator and the gas in the exhaust; to operate automobile auxiliaries; and to overcome friction in gears and tires.

For solar radiation, this balance is indicated by the estimated quantitative input and output shown in figure 1.7.

3. Energy and the Global System

The energy inputs into the surface of our globe are mainly from three sources:

1. the energy from the sun, received through solar radiation;

2. the energy associated with oceanic tides and tidal currents resulting from gravitational interaction between the earth, the sun, and the moon;

3. the energy from the interior of our globe in the form of hot springs and volcanoes.

An estimate of the percentage each source contributes to the total energy input is indicated in figure 1.6. Solar energy is by far the major source of energy input. It enters the earth's atmosphere as sunlight (short-wave lengths), is distributed over the earth's surface through the circulation of the atmosphere and oceans, and finally returns to space in the form of heat energy (long-wave lengths). Since the energy re-radiated to space equals the energy input, there is an energy balance.

Haste Makes Waste: Pollution and Entropy

What goes in
Must go out
Or Pile up,

There are no CONSUMERS
Of mass or Energy,
Only CONVERTERS.

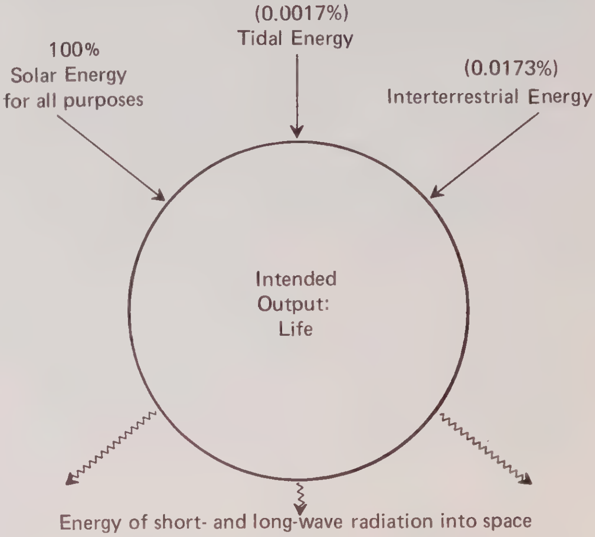
We need to ask more often
What do we do with the
Converted mass and energy?

Throw it away, we used to say. But
There is no "away".
THE EARTH IS FINITE.
One man's dump
Is another man's living space.
Sewers, chimneys, and tailpipes
Produce private splendor
And public squalor.

Henry A. Bent, "Energy and the Global System", *Chemistry* 44, no. 9, p. 9. Reprinted by permission of the American Chemical Society.

★ Through discussion, show how figures 1.6 and 1.7 and this poem are related.

Figure 1.6



Source: Gabel Medard et al, *Energy, Earth and Everyone: A Global Strategy for Spaceship Earth* (San Francisco: Straight Arrow Books, 1975), p. 20.

★ Consider figures 1.5 and 1.7.

– What solar energy absorption process has contributed the most to our major proven energy sources (fossil fuels)?

– Approximately what percentage of solar radiation is absorbed in the process? What fraction is this of the total solar energy absorbed by earth?

– Why are there limits to these proven energy sources?

– What is one proven alternative energy source? What are the limits to this source?

– What are some alternative energy sources to the proven sources? Which solar absorption line in figure 1.7 would they relate to?

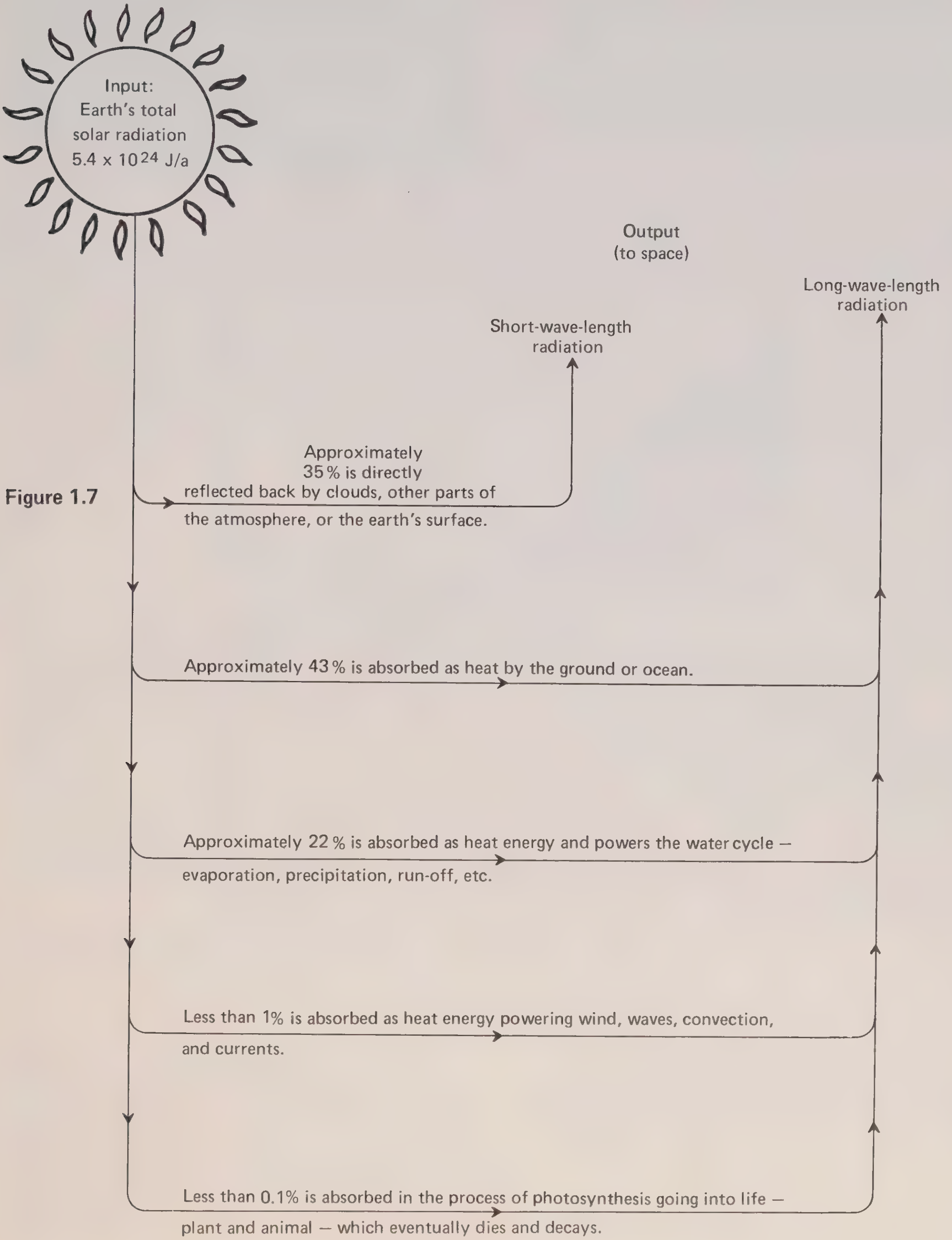

Input:
Earth's total
solar radiation
5.4 x 10^24 J/a
Output
(to space)
Long-wave-length
radiation
Short-wave-length
radiation
Approximately
35 % is directly
reflected back by clouds, other parts of
the atmosphere, or the earth's surface.
Approximately 43 % is absorbed as heat by the ground or ocean.
Approximately 22 % is absorbed as heat energy and powers the water cycle —
evaporation, precipitation, run-off, etc.
Less than 1% is absorbed as heat energy powering wind, waves, convection,
and currents.
Less than 0.1% is absorbed in the process of photosynthesis going into life —
plant and animal — which eventually dies and decays.

Figure 1.7

Source: Adapted from Gabel Medard et al, *Energy, Earth and Everyone: A Global Strategy for Spaceship Earth* (San Francisco: Straight Arrow Books, 1975), p. 20.

4. Canadian Energy

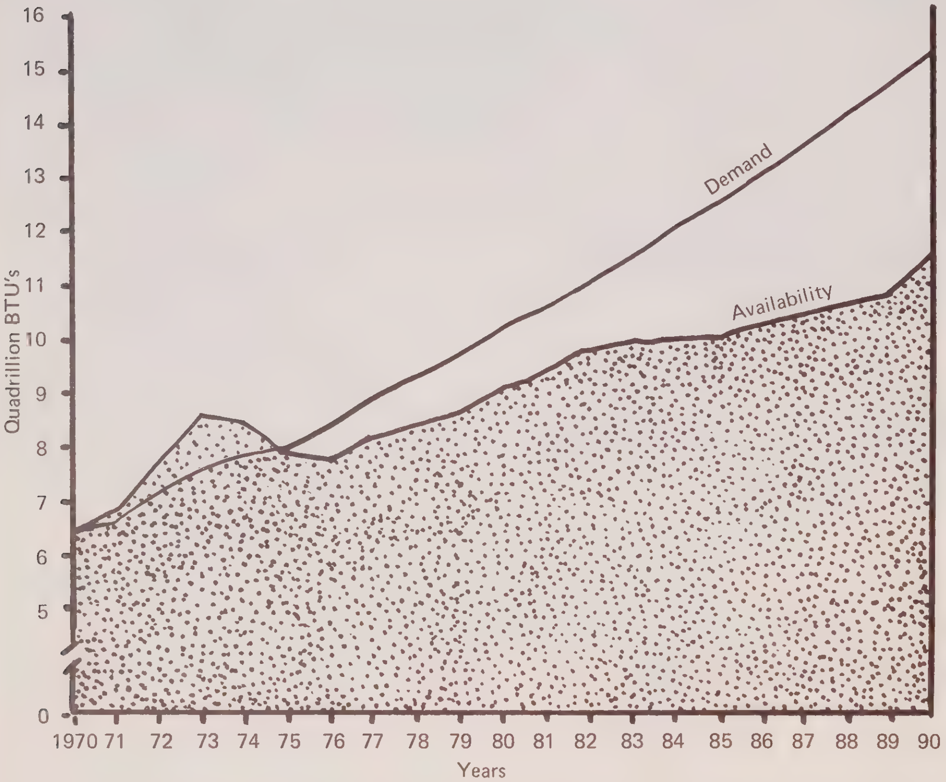
Can we meet domestic demand with domestic supply? In 1975, Canada used more energy per capita than any other country. Our very comfortable life style appears to depend on a high energy consumption. Newspapers, TV, and other news media deal increasingly with our need to conserve energy. Do we really need to? Doesn't Canada possess ample available energy supplies? The next few activities will lead students to consider these questions and to formulate their own answers.

★ Table 1.4 could be completed. Notice that fossil fuels provide the bulk of Canadian energy. Discuss why this would be the case when, as indicated in figures 1.6 and 1.7, the earth's greatest source of energy is from the sun.

★ Ontario has harnessed nearly all of her rivers with hydro-electric generators. We are nearing the maximum of our hydro-electric capabilities. Discuss how the sun's energy makes hydro-electric power possible. What are ways of utilizing the sun's energy other than through hydro-electricity?

Figure 1.8

Domestic demand and availability: total energy (1970-1990; low-price option)



Source: Department of Energy, Mines and Resources, *An Energy Strategy for Canada* (Ottawa: Publishing Centre, Supply and Services Canada, 1976), p. 75.

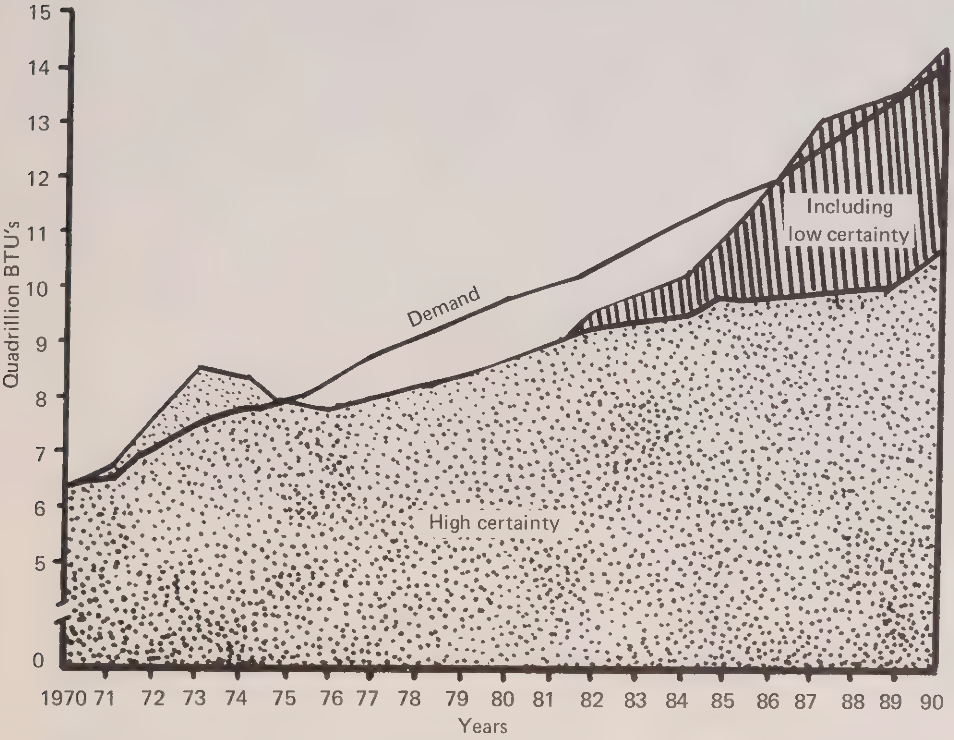
Figure 1.8. In this projection, it is assumed that the price of energy (oil, gas, electricity, and coal) in Canada remains at end-1975 levels. It increases only at the general rate of inflation and does not increase at a faster rate than other goods and services.

Energy Demand and Availability Implications

★ Examine carefully figures 1.8 and 1.9 which express the projected future supply and demand of energy in Canada. What are your reactions to the implications of the two graphs? How do you feel about Canada's energy future? Do you think Canada, as a nation, will become self-sufficient?

Figure 1.9

Domestic demand and availability: total energy (1970-1990; high-price option)



Source: Department of Energy, Mines and Resources, *An Energy Strategy for Canada* (Ottawa: Publishing Centre, Supply and Services Canada, 1976), p. 82.

Figure 1.9. In this projection, it is assumed that the price of energy increases relatively faster than the prices of other goods and services until about 1978 when oil reaches a level roughly equivalent to the current international price. After 1978, all energy prices are assumed to increase only at the general rate of inflation. It is assumed that the higher energy prices would enable oil companies to finance exploration and development in Canada's frontier areas in order to produce substantial new supplies of energy.

Table 1.3

Estimated Canadian domestic energy demand and availability	1980			1990		
	A	B	C	A	B	C
	In quadrillion BTU's	In 10^{18} joules	Equivalency in barrels of crude oil	In quadrillion BTU's	In 10^{18} joules	Equivalency in barrels of crude oil
Low-price: Demand						
Availability						
Difference						
High-price: Demand						
Availability						
Difference						

1 barrel of crude oil contains 6.12×10^9 J
1 BTU = 1.055×10^3 J

Exploring Canada for New Sources

★ Notice that more energy is available in 1990 in one forecast than in the other. Why would this be the case? The underlying assumption is that with less chance of developing Canadian domestic oil supplies, there will be a change-over to electrical energy. This increased demand will give the electrical utilities the support to expand their generating capabilities and move closer to their maximum capability. Notice also that with billions of dollars spent on exploration and development, the outcome is considered "low certainty". Discuss this and decide what you consider to be the best alternative: to risk billions on seeking oil (as in figure 1.9); to do nothing (let nature take its course, as in figure 1.8); or to find some other solution, such as developing alternative sources of energy such as solar, wind, and tidal energy. Use facts to support your reasoning.

Renewable Sources of Energy

★ Use the information given in table 1.4. First express each source of energy as a percentage of the total amount of energy converted. In the year 1990, it is expected that some renewable sources will be added to the sources listed in the table. Identify some of the renewable energy sources that might be listed among the alternatives. Only one of the sources listed is renewable. Which one is this? List all the sources of energy that you feel will be available in the year 2050, indicating what percentage each source will make up of the total amount of energy used at that time.

Ways of Establishing Canadian Energy Self-Sufficiency

Now that we have considered the Canadian energy problem, we shall look at why the issue of trying to "conserve" so as to become self-sufficient is important. If our demands for energy exceed our supply, Canada will have to continue to be an importer of energy . . . and we will have to pay the price. Billions of dollars will leave the country – money that we cannot afford to lose – and we will become dependent on the oil-producing countries, which is unacceptable.

> One of our basic problems is a growing dependency on crude oil. Conventional crude oil is coming into shorter supply in Canada and that means we have to purchase it from foreign sources; at the same time the price is soaring. If we maintain our present course, we can look forward to ever greater trade deficits and further energy induced inflation in the years ahead. An increased dependency on foreign oil could further damage our industries bringing up the cost to where we could not compete in world markets.
>
> D. Timbrell "Energy in Ontario", Man-Environment Impact Conference, Toronto, November 1976.

★ Complete table 1.3 and discuss the implications of the differences.

Table 1.4

Sources of Present Canadian Energy Consumption (Amyot 1976)		
Source	**Energy consumption equivalent in 10^{15} joules**	**% of total**
Petroleum	3966.8	
Natural gas	1804	
Coal	762.8	
Hydro-electricity	869.3	
Nuclear electricity	177.2	
	Total $\times 10^{15}$ J	100%

Source: Kimon Valaskakis, Peter S. Sindel, and J. Graham Smith, *The Selective Conserver Society, Integrating Report: Second Phase,* vol 1, p. 49 (Ottawa: *Conserver Society,* 1976). In other references, this publication will be referred to as the *Gamma Report.*

> *Ways to Self-Sufficiency – A Federal Government Perspective*
> In support of the objective of energy self-reliance within ten years, the Government of Canada proposes nine major policy thrusts. These policy elements provide a co-ordinated framework for the development of specific programs and measures. They include:
>
> 1. appropriate energy pricing;
> 2. energy conservation;
> 3. increased exploration and development;
> 4. increased resource information;
> 5. interfuel substitution;
> 6. new delivery systems;
> 7. emergency preparedness;
> 8. increased research and development; and
> 9. greater Canadian content and participation.
>
> From Department of Energy, Mines and Resources, *An Energy Strategy for Canada: Policies for Self-Reliance* (Ottawa: Publishing Centre, Supply and Services Canada, 1976), p 126.

Together with the objective of self-reliance and the various policies that will lead to this, the government of Canada has adopted various targets. The target for policy (2) is a measure which all of us can support by adopting conservation practices:

> To reduce the average rate of growth of energy use in Canada, over the next ten years, to less than 3.5 per cent per year. This can be attained by appropriate pricing measures and energy conservation initiatives. It represents a reduction of the historically observed growth rate by over one third. It is a reduction which is technically feasible with a minimal impact on our standard of living and quality of life. It is a reduction which is essential if we are to be able to plan our energy future in the most appropriate way. Over the next year or two, as the performance of the Canadian economy accelerates, the growth in energy consumption may exceed 3.5 per cent per year. As we approach steady economic growth at potential and as the results of energy conservation initiatives take effect, it is expected that the rate of growth of energy will fall below 3.5 per cent per year.
>
> From Department of Energy, Mines and Resources, *An Energy Strategy for Canada: Policies for Self-Reliance* (Ottawa: Publishing Centre, Supply and Services Canada, 1976) p. 147.

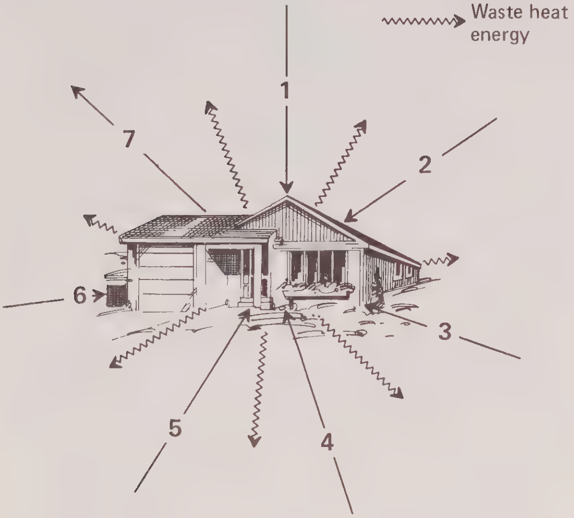
This document describes many appropriate conservation initiatives that may be undertaken by an individual or group within a home or school. Since most of the other policy elements require governmental action, they are not dealt with extensively ★ here. Students, however, could profitably research those specific programs and measures that are associated with each of the policy elements.

5. Energy and Our Home Systems

Figure 1.10 shows the home as the terminal for six systems and the starting point for one. The seven systems interact extensively, but for convenience they can be examined separately. Each system requires energy to function. Each of us is an important part of the system, since our habits – be they frugal, temperate, extravagant, or wasteful – determine in part how fast each system operates and how rapidly the resources that feed into the system are used. Since each system needs energy to operate, the greater our demands on the system, the greater the rate at which energy is converted into low-grade heat energy and dissipated to the environment. To conserve energy, we could turn off a system or even all the systems.

Figure 1.10

Some Home Energy-Converting Systems



1. Fossil fuels – space heating
2. Agriculture-food
3. Manufactured goods
4. Petroleum-transportation
5. Hydro- / Nuclear-reactor / Fossil-fuel → electricity
6. Water
7. Waste disposal

The concept of a conserver society is a Canadian contribution to conservation literature. It was put forward by the Science Council of Canada "to communicate where our thoughts and ideas lie at this time and, more important, to stimulate the national debate and discussion". The term is now frequently used in the news media. It gives a direction to our conservation efforts as well as an indication of what could be our future energy life style. It merits debate and discussion.

The Conserver Society: An Operational Definition

The concept of a Conserver Society arises from a deep concern for the future, and the realization that decisions taken today, in such areas as energy and non-renewable resources, for example, may have an irreversible and possibly destructive impact in the medium to long term.

The necessity for a Conserver Society derives from our perception of the world as finite and of non-renewable resources as limited, as well as from our recognition of increasing global interdependence.

A Conserver Society is on principle against waste. Therefore, it is a society which:

– promotes economy of design of all systems, i.e., "doing more with less";

– favors re-use or recycling and, wherever possible, reduction at source;

– questions the ever-growing per capita demand for consumer goods, artificially encouraged by modern marketing techniques; and

– recognizes that a diversity of solutions in many systems, such as energy and transportation, might, in effect, increase their over-all economy, stability, and resiliency.

In a Conserver Society, the pricing mechanism should not just reflect the private cost, but rather should reflect the total cost to society, including net energy used, ecological impact and social considerations. This will permit the market system to allocate resources in a manner that closely reflects societal needs, both immediate and long term.

From Science Council of Canada, *Conserver Society Notes 1:2* (December 1975), p. 3.

D. A. R. Thompson extends the concept as follows:

> The conserver society is inevitable. If we do not make conscious decisions and take conscientious action to conserve limited resources, to live within ecological and climatological constraints, and to address the sociological problems associated with massive technological developments, changes will be forced upon us. . . . The conserver society can only become clearly defined, it can only become a reality, with public involvement and public commitment. The conserver society would not be a harsh, primitive struggle with the elements but would be richer in both material and cultural aspects because of an emphasis on quality rather than consumption.
>
> D. A. R. Thompson, "The Conserver Society: An Inevitability", Man-Environment Impact Conference, Toronto, November 1976.

The next few pages will suggest ways in which the teacher might bring a degree of understanding of the conserver society to students through debate, discussion, and active involvement in terms of the systems concept and the student's home.

★ Consider figure 1.10. To conserve, could we turn off a system or even all systems?

6. Forcing Functions and Constraints

The teacher might discuss the implications that turning off each individual system would have on one's life style. Would such an extreme measure be compatible with a conserver society? How would each system be regarded and used within the context of a conserver society?

Each home system may be seen as having pressures on it that make resources flow through it faster and that cause energy to be consumed at a faster rate. Conversely, there are factors that can impede an increase or even slow down the flow of energy. The former will be referred to as forcing functions and the latter as constraints. The following list is not exhaustive:

Forcing functions	*Constraints*
– population (p. 19)	– values (p. 20)
– demand (p. 19)	– technology (p. 21)
– rising expectations (p. 19)	– the environment (p. 21)
– new developments (p. 20)	

What others might be added to these lists?

Forcing functions and constraints interact extensively. An analysis of why one family is wasteful and another family conservative in their demands on a system indicates that many, if not all, of the above forcing functions and constraints play a part. Students can be made aware of this interaction through the kinds of discussion and involvement suggested on the following pages.

Population

★ A discussion can be held on the many ways in which a new arrival in the home – whether a baby or a brother-in-law – will speed up the flow rate of each system. Discussion can centre on the implications of zero population growth and how the values some people hold towards family size might influence the population of a home. How other constraints might reduce or increase family size should also be considered.

Demand

We often fail to distinguish between needs and demands. Needs are what we really require to live comfortably. Demands include needs and the many unnecessary things we acquire and do. Students should be able to make this distinction:

Needs = Demands – Non-essentials

★ To illustrate this point, list twelve home appliances that require electrical energy to operate. List four that you could give up readily. List four that you would find very hard to give up. Which two of these would you keep to the last? Which one would you give up last? Is there any consensus among students with regard to the last one? Which ones kept to the last might be considered unessential? Discuss these and the following quotation in terms of the flow rate of energy in a system.

> ★ The second source of high residential energy consumption is the electrical consumption associated with household appliances. The proliferation of household appliances has been a major characteristic of the mass consumption society. Our life style seems to demand it. To reduce this demand we will have to alter our behaviour patterns and/or produce more efficient household hardware.
>
> From the *Gamma Report.*

★ Discuss this statement:

> The first thing is to get our energy needs into a proper relationship with real needs.
>
> From Walter Pitman, "Politics, Ethics, and Ecology", Man-Environment Impact Conference, Toronto, November 1976.

★ Discuss some of the relationships between demand and other functions and constraints.

Rising Expectations (Stimulated by Advertising)

★ Collect advertisements from the local newspapers – advertisements that suggest that people might be happier if they were to purchase a certain item. Identify the phrases that suggest that satisfaction, the better life, happiness, etc., is yours if you acquire the object being sold. Discuss whether this is true.

★ Advertisements on television could be noted or taped over several evenings and then played back in class. The class might discuss how these advertisers openly or subliminally suggest that life can be made more satisfying through the use of their product. Discuss how advertising influences the flow rate of goods in the manufacturing system.

> I go into despair whenever I think of this. Who has control of the media on which we base our values? Who buys the newspapers? You and your 10 or 15 cents? No way. Who buys the TV you watch when you buy your set? You? No way. We only communicate to each other through the people who operate the consumption society par excellence. Advertising is the fuel for the consumption society.
>
> From Walter Pitman, "Politics, Ethics, and Ecology", Man-Environment Impact Conference, Toronto, November 1976.

Using the advertisements you have collected, support or refute Mr. Pitman's statement.

★ The following was included in a CBC television presentation aired in 1976:

> For many years in Ontario the Ontario Hydro ran commercials telling us to live better electrically by using much more electricity. Ontario Hydro offices often displayed electricity-consuming appliances which Hydro customers could purchase and so be assisted in living better electrically. Now we are receiving the following commercial: "Over the years the people of Ontario have been demanding more and more electricity. Every 10 years the demand for electricity has doubled – and Hydro has kept pace by doubling its generating capacity every 10 years. But that is all over now. Hold it. There simply are not enough resources for that kind of growth. We've got to slow down. Save all the electricity you can."
>
> Patrick Watson, CBC.

Discuss why there would be such a dramatic change in Ontario Hydro's advertisements; how the first message may come back to haunt us; and whether the second message will really change people.

★ Consider the relationships between rising expectations and other functions and constraints.

★ Discuss the consumer credit card in terms of personal satisfaction and the flow rate of energy in a system.

New Developments

★ Discuss the following questions regarding new developments:

– Experts inform us that there is enough oil in the tar sands of Alberta to look after Canada's energy needs for two centuries. Unfortunately, the technology to remove the oil in an economical and environmentally sound way has not been found. If it were to be found, in what ways would it influence a system's flow rate?

– Would you be supportive of conserving oil? If there was enough for eight generations, would you worry about the ninth generation?

– Discuss the effect that new electronic game attachments for television sets, hand calculators, digital watches, and other innovations have on our house systems' flow rates.

Values

★ I grew up during hard years and never had trips and cars or even candy. I had a lot of injustice done to me. Now I have it made. I have lots of money, a yacht, an estate with a home having five bathrooms, four tennis courts, an indoor pool, an outdoor pool, and three cars. I have a fully equipped northern cottage and another down in Florida. I read in the paper that I should change my values and become a conserver doing "more with less", whatever that means. Let me ask you this: Why should I change my life style? Why should my wife and two children change? My neighbour down the street has bought two Lincoln Continentals. He is going to get a lot of satisfaction out of them. You know what? Tomorrow I am going out and get two also!

★ Discuss this statement using the following questions:

– How would you reply to the speaker? Identify some of his values in the process of replying. If the credo of the conserver society is to "do more with less", this gentleman's credo would be to "do less with more". We could say that he is a member of the "squander society". Discuss how his values influence energy flow through the system.

– Are you a member of the squander society? List ten items that you own and use for recreational purposes and five items you would purchase if you had the money. Beside each, indicate the amount of time that you have used the item during the past week. List four items that you own and hardly ever use. Do you feel that there is waste in your ownership? What values are necessary if we are to do "more with less"?

> This "ownership waste" is most prevalent in our society. At any one point in time there are masses of unused goods in our possession. This includes cars parked in the driveway, clothes hanging in the closet, unread books on the shelves, unplayed records, empty summer homes in winter, empty winter homes in summer. . . .
>
> The Canadian summer cottage is an excellent example of ownership waste. By the time it has been opened-up, the winter damage repaired, all the summer things cleaned and oiled (boats, motors, garden things) the black fly season has arrived or, more probably, the summer is over.
>
> From the *Gamma Report*, vol. 1, p. 222.

As we acquire more and more material goods, the amount of time we have to spend with each is less and less. The materials and the energy that have gone into the production have been used for a questionable purpose.

★ Have each student make a list of items under the heading "My Personal Ownership Waste".

★ One way to do more with less is to rent things instead of buying them. Most people own major items which are used very little. Snow blowers, outboard motors, and lawn mowers are examples. Discuss how renting goods rather than purchasing them would reduce the flow rates through the various systems.

★ After reading the following quotation, consider in turn the first, second, fifth, and sixth sentences. Do you agree or disagree with each? Support your positions with facts from *your* personal experience:

> The object of acquiring goods is to experience and enjoy them. This should not necessarily be tied down to ownership. Roman Law identified three characteristics of property rights: *usus*, or the right to use, *fructus*, or the right to enjoy the fruits of the product and *abusus*, or the right to alienate, abuse or destroy. Renting conveys the *usufruct* (use and enjoy) but not *abusus*. In the Conserver Society no form of abuse should be tolerated. Stiff fines should be levied against all those who destroy or misuse their possessions, whether personally owned or not.
>
> From the *Gamma Report*, vol. 1, p. 224.

★ The following describes an extreme form of renting-to-conserve philosophy. Here ownership has been reduced to a minimum.

> *A Mini-Scenario of the Rental Society*
>
> In California, it is reported that a condominium apartment building exists in one of the beach-resort towns where consumer goods are all shared. On the first floor is a gigantic boutique where clothes are chosen on Monday for the week. A fleet of cars in the garage allows the aesthetic coquette to match her chosen car to the colour of her dress rather than vice versa. Books on all subjects exist in the library on the second floor and a lending record library exists on the third. Colour television is rented for the rainy nights, while in midsummer the residents may either perfect their tennis on the communal tennis courts, learn aquatic sports from a variety of skilled instructors or sail a yacht for the weekend (the waiting list for this last item is very long).
>
> A family on the seventh floor has rented an authentic Picasso for six months, the girls in Apartment 54C have a living room full of rented soapstone carvings and a complete set of genuine Navaho ritual jewelry. The young executives in 715A are ensconced in a Louis XV salon.
>
> Adapted from the *Gamma Report*, vol. 1, pp. 224-5.

★ Discuss this scenario using the following questions:

– What do you dislike about this society?

– What do you like about it?

– What values do you possess that would prevent you from living this way?

– How would this society influence the flow rate of our manufacturing system?

★ How do one's values influence the flow rates through the systems?

Technology

The following activity will help students appreciate how technology can be used to reduce energy consumption in their homes. Since whether or not to use technology is usually a personal decision, the example used considers technology in association with values and attitudes. Students could work in groups acting as families and thus discuss each option to arrive at a decision.

★ In going over the household accounts, your father notes that in the previous year 3600 L of #2 fuel oil, at a cost of $340.00, were required to heat your home. He anticipates that with the increase in fuel costs he will need to pay $140.00 more this year. From all indications, the cost of fuel oil will be much higher in the next heating season. Like most householders, he has been collecting Federal Government publications on how to save energy and has made the following notations:

1. Valid sources claim that the following action on our part will lead to the given saving of fuel:

a) Lowering our thermostat setting from the present 22°C to 20°C and for another eight hours each night lowering it another 3°C	11%
b) Having our furnace tuned twice a year	10%
c) Insulating our attic to recommended levels	10%
d) Insulating our walls to recommended levels	4%
e) Insulating our basement to recommended levels	9%
f) Adding caulking and weatherstripping as needed	5%
g) Adding storm doors	2%
Total saving	51%

2. Insulating the walls will cost $600, since an expert is required to do this work.
3. We can do all the rest of the work ourselves.
4. Having the furnace cleaned twice a year will cost $50.00.
5. Material for all but the walls at today's prices will cost $640.00.
6. There will be no end to the increase in the cost of fuel.
7. If every household saved 50% of its fuel, Canada would have more time to seek alternative sources.

Option 1. Your family has $600, but it was decided last year to save for a heater on the swimming pool. What would be your family's decision?

Option 2. Your family feels it should insulate the house this summer, but does not have the money to do this. However, you have saved $600 in order to visit Europe next month with the school band. If you were not to go, the house could be insulated. What would be your family's decision?

Option 3. Your family has $600. The money should be used to insulate the house; however, since your father works with an oil company you get your fuel at 40% off. It is still inexpensive compared to what others pay. Should you use the money to insulate or take the summer trip that you have planned?

Discuss whether the decision made by each family was rational and what values were reflected by the various members of the family.

★ The technology to insulate our homes is known. Discuss how applying it can influence the fossil-fuels – space-heating flow rate.

The Environment

It costs less to extract and refine resources that are close to the consumer. As a resource is depleted, exploration for new supplies goes on, and if found, they are usually farther from the consumer. Gradually the exploration and extraction moves outward. This has happened in the case of many natural resources, crude oil and natural gas being the best examples.

Presently, petroleum exploration and extraction is moving into the far Northwest and into the North Atlantic. This has resulted in, among other things, an increase in environmental risks. The negative impact of man as he extracts materials from the delicate tundra region is of great concern. The following materials will enable a student to consider the physical, political, economic, and cultural impacts that system expansion has on the environment.

Can You Separate Oil From Water?

★ Fill a dishpan with water, and with an eyedropper place one drop of oil in the centre of the pan. Make a list of the different ways you can devise to remove the oil from the water. Indicate as well which methods might be used to remove oil spills from Canadian coastal waters. What modifications would have to be made to these methods in order to use them on the large scale?

★ *The Arrow Oil Spill*
In February 1970, the oil tanker *Arrow* ran aground off the coast of Nova Scotia, spilling 77 000 barrels of oil into the waters of Chedabucto Bay. This initiated a heroic effort by Canadian scientists and the Canadian Coast Guard to limit the extent to which the neighbouring coast line would be polluted.

By investigating old newspaper files, find out what measures were used to "mop" up the oil and how successful they were. Were there sections of coastline that were not able to be saved? Who paid for the costs of the "mop-up"?

★ *Oil Spills and Environmental Damage*
On June 23, 1976, a barge owned by the New England Petroleum Company spilled 7445 barrels of oil into the St. Lawrence River at Alexandria Bay, near the town of Gananoque, Ontario. The oil cost $10 000 000 to "mop" up. Many wildlife refuges in the area were thoroughly polluted, and since the cost of cleaning them up was too high, they have been left polluted.

Investigate what harm oil spills can do to the wildlife in the area of an oil spill.

Oil Spills: An Increasingly Serious Environmental Problem

December 15, 1976 – the Liberian tanker *Argo Merchant* sinks off Nantucket Island, Massachusetts, spilling 210 000 barrels of oil into the seas.

December 17, 1976 – the Liberian tanker *Sansinena* blows up in Los Angeles harbour, killing 9 and injuring 50.

December 19, 1976 – the Panamanian tanker *Grand Zenith* leaves Teesport, England, for Somerset, Massachusetts, carrying a crew of 38 and a cargo of 220 000 barrels of oil. It is now believed to be lying at the bottom of the Atlantic off the northeast coast of the United States.

December 24, 1976 – the Liberian tanker *Oswego-Peace* leaks 55 barrels of diesel oil from its fuel tanks into the Thames River at New London, Connecticut.

December 27, 1976 – the Liberian tanker *Olympic Games* leaks 3700 barrels of Arabian crude oil into the Delaware River, 15 miles from Philadelphia.

December 30, 1976 – the Liberian tanker *Daphne* runs aground off Puerto Rico. Her holds emptied, she is pulled off the reef with no oil getting into the sea.

January 7, 1977 – the Liberian tanker *Mary Ann* is rocked by an explosion while her tanks are being cleaned 300 miles east of Norfolk, Virginia. One sailor is hurt, but the ship is not seriously damaged.

To understand the immensity and importance of the problem, calculate how many gallons of oil were spilled into North America's coastal waters because of these incidents, and how many people lost their lives in the spills. Such a large number of spills in such a brief time interval led to a number of editorials deploring the situation. How do you feel about the situation? Consider whether, for instance, the use of energy-conservation practices by Canadians would diminish the underlying problem. What steps might be necessary if the problem is to be removed? How reasonable are your answers?

Oil Imports and Oil Tankers
It is expected that Canada will need to import crude oil to meet its domestic demands in 1980.

★ Consider the following questions:

– If we are entirely dependent on oil imports, approximately how much energy would this be in quadrillion BTU's? (Examine figures 1.8 and 1.9.)

– If we required 17 000 000 barrels of oil, how many tankers the size of the *Grand Zenith* would be required to deliver them?

– What are your predictions for increased oil spills in Canadian waters?

– If Canada were to attempt to enforce increased safety regulations, would she be accused of "gunboat diplomacy"?

– What would this mean?

– In view of our increasing dependence on foreign oil, could we really impose unilateral safety regulations?

Would Increased Safety Standards Help?
Among the general Canadian public there seems to be considerable feeling that oil tankers of foreign registry should be barred from Canadian waters unless they comply with more rigorous safety standards.

★ Investigate to find out:

– what our present safety standards are;

– what safety standards are required;

– how our Canadian safety standards have to be improved; and

– what the procedures are for improving our Canadian standards.

Energy Sources and Associated Pollution Problems
While oil spills constitute one major environmental problem associated with our need for more energy, there are other major concerns.

★ By completing table 1.5 students will gain insight into the extent of the environmental problems associated with our energy use. In each case, students should consider the whole energy system that brings the energy to their homes. For example, in the case of fuel oil, this would include: exploration, drilling, pumping, transportation to the refinery, refining, and so on.

Table 1.5

Energy Source	Type of Environmental Pollution				Landscape (Aesthetic) Degradation
	Air	Water	Noise	Thermal	
Petroleum					
Coal					
Fuel oil					
Natural gas					
Gasoline					
Diesel oil					
Hydro-electricity					
Nuclear electricity					

7. Slowing Down the System

Danger Signs

★ The following statement was made at the Man-Environment Impact Conference held in Toronto, November 1976:

> Thus far, we have escaped widespread retribution for environmental neglect because the global ecosystem is vast and resilient and has coped with our depredations. But the danger signs are becoming more obvious. Destruction of forests and over-grazing are leading to desertification; world fisheries – ranging from whales to anchovies – have been severely depleted; industrialized countries have turned great rivers into open sewers; and we may even have devised ways to damage the ozone layer. What level of human activity can tip the environmental balance is not yet determined. However, what is clear is that if we discount all such risks, if we fail to make adequate cost allowances for maintaining our environmental capital, we will not simply suffer bankruptcy, we will suffer disaster. The price of our neglect will be the destruction, or the massive degradation, of human life.
>
> From Maurice Strong, "Northern Energy: A Fragile Giant", Man-Environment Impact Conference, Toronto, November 1976.

Students could discuss the emotions and feelings that may have motivated Maurice Strong when he said this. Many people agree with him while many others do not. What position do your students take? They should give reasons for their positions.

Economic, Social, and Political Factors

We have considered constraints mainly as factors that reduce the flow rate in a system. They may also serve as constraints *against* a reduction in the flow of energy. Students may gain an insight into the importance of economic, social, and political factors by considering the role each could play in the foregoing activities as inhibitors or facilitators of the flow rate in a system. Issues such as the Alaska Highway Pipeline, the Mackenzie Delta Project, the CANDU Reactor, the Garrison Diversion Project, smaller automobiles, and other issues current in our newspapers could also be considered. The text used with "Canada's Northern Gas Resources: Is There An Acceptable Solution?" and "The Canadian National Energy Board: A Simulation" in Part 2 lends itself well to such an examination.

After completing the activities contained in this resource material, students will be aware of our need to employ energy-conservation practices. Awareness and understanding are not enough, however. These must also be reflected in the students' life styles. The next few pages will allow students to obtain some measure of their present commitment. They will also suggest steps whereby concern and understanding may be turned to action.

★ By working in small groups, identify fifteen energy-consuming appliances or devices that your family uses. List and consider them in a table like table 1.6. Be frank and factual.

How did your group rate on its present application of energy-conservation practices? How does your class rate? Discuss the attitudes, feelings, and habits that might prevent people from applying conservation practices.

★ A discussion of the following story and figures 1.8 and 1.9 could be used to introduce ways to slow down the system:

> There was a remarkable story on a very human, personal level that came out of South America several years ago. It was an account of a Uruguayan rugby team travelling by plane to Chile; the plane crashed in the Andes. Many of the people were killed, but many were left alive and they were left alive with the shattered hulk of a plane. Some of them were injured and some were not, so they divided up, with the more injured ones inside the plane for protection in this cold environment and the less injured ones outside most of the time.
>
> They had enough technical ability so that they managed to get their receiving radio operating, but they did not have enough ability to get the sending radio operating. They could listen to what was going on, and the people outside were listening day after day to the accounts of the search. However, it is a big region and a plane is a very little object, so day after day went by and they were not found.
>
> Finally, the day came when the people in charge of the air search concluded that it would not be possible for anyone to be still living, assuming that they had survived the crash. Over the air came the announcement that the Chilean air force had called off its search for the downed plane.
>
> When this had happened, the people outside listening asked, "What will we do? What will we tell our friends on the inside?"

Table 1.6

Energy-consuming device	Conservation practice that you could use with this device	Self-rating on your present application of the conservation practice (excellent, good, acceptable, poor)
1.		
2.		
etc.		

> One said, "We can't tell them; it would break their hearts."
>
> Another said, "No, we have got to tell them." He got up and walked inside the plane and he said, "Hey fellows, great news."
>
> They asked, "What is it?"
>
> "They called off the search for us."
>
> At this point there were groans inside the plane. They answered, "What do you mean great news? That's terrible."
>
> "No," he replied. "Don't you see: now we are going to have to make it on our own."
>
> This represented a turning point for the group. Once they knew that nobody was going to help them, they set out to make it on their own and they did make it.
>
> Adapted from Garret Hardin, "Carrying Capacity: The Central Ethical Concept", Man-Environment Impact Conference, Toronto, November 1976.

For many Canadians the publication of the two graphs (figures 1.8 and 1.9) has been a turning point. We now know where we stand. No one from the outside will solve our domestic energy problem. We will only solve it if we work together and change our individual and national energy-use habits.

What can we do? There are many personal conservation measures that each one can employ. The parts that follow this introductory part will consider these in detail. There is much more than the cultivation of sound, personal energy-use habits. We can work together to help others to conserve energy. We can become sensitive to environmental issues that have adverse implications for our energy supplies and move to bring them before the public.

> I am becoming more and more convinced that the environmentalist really has to be a neighbourhood worker – a neighbourhood activist.
>
> From Walter Pitman, "Politics, Ethics, and Ecology", Man-Environment Impact Conference, Toronto, November 1976.

Action Steps

★ The following are activities for students that can be used to bring about change or to prepare them to bring about change by developing an energy ethic.

1. Sponsor an energy-conservation week in the community, focusing attention on energy by giving talks in classrooms of your school, appearing on radio and TV, getting the local newspapers to print important energy articles and materials, urging local stores to put energy-conservation displays in their windows, and conducting public energy-conservation forums.

2. Launch an annual school energy-conservation fair and award plaques to winners for the best ideas for saving energy in some aspect of the following home systems: space heating, food, transportation, water, electricity, manufactured goods, and waste. This could be an exciting project. It creates interest in and publicity for energy conservation and contributes to good, personal energy-conserving habits.

3. Conduct a school-wide or board-wide energy-conservation contest.

4. Obtain films dealing with energy and its conservation, view them, and discuss them. The films could be shown in the evening so that interested members of the community might attend.

5. Organize an energy team that includes teachers, pupils, and members of the community. A school energy team might have the following representation:

a) a representative of the administration – principal or vice-principal;

b) a representative of the operation – senior custodian;

c) representatives of the users – two teachers and two students; and

d) a representative of the community (if the school has a heavy community use).

This team could request from the school board all available information concerning the energy used and the operating costs of the building. It might then draw up a list of procedures and practices that it believes will allow the school to function efficiently and also to conserve energy, where reasonable. The team might assist in making all decisions related to the use of energy and the behaviour of the occupants of the building. It might draw up a set of guidelines for all occupants of the building and seek to persuade all who use the school to co-operate and help.

It is essential that the team obtains updated information on a regular (monthly) basis to see how its energy practices are affecting the consumption of the various forms of energy input into the building. It is probable that the team would desire to review its procedures on an on-going basis.

Once this team has demonstrated its effectiveness, it is possible that a conservation club might be formed in each class. This class club could be kept informed by the energy team of the success of their joint efforts and could be encouraged to assist in promoting good energy practices, both in the school and throughout the community. The energy club, with its involvement of youth, can be a vital force for shaping the community's long-term energy ambitions. Clubs can reduce or prevent the kinds of energy shortage that historically occur when waste is allowed to continue unchecked. They can also be a lot of fun.

6. Set up a clearing house of information on energy-conserving practices and projects.

7. Encourage community libraries to set up small energy-conservation rooms or corners, where useful material on energy conservation can be made easily and conveniently available to interested people.

8. Donate information, books, and articles on energy conservation to the community or school library.

9. Recommend to local cub, scout, and brownie groups that they offer an energy-conservation badge with you or the energy team acting as counsellors for the badge.

10. Be aware of violations of the energy ethic in your community. Consider action plans that would correct these.

11. Keep in close touch with federal and provincial developments by obtaining and reading government publications. (Some of the publications are listed in the bibliography.) Know what is being planned at these levels and be ready to raise your voice for or against the measures that enhance energy-conservation or are prejudicial to it.

12. Recognize that knowledge and understanding are basic to any energy-problem solutions. Enlarge your grasp of the technical aspects of the problem. People with good intentions often lose the battle because they do not have their facts straight.

13. Don't assume that you as an individual can't contribute. Many large conservation projects have been initiated by one individual.

14. Develop a local energy-saving project, such as attempting to alert every household in the school's community to the fact that lowering the thermostat saves fuel. Brainstorm ways of bringing this saving about (letters, tags to place on thermostats, etc). Carry the project out.

15. Set a good example for others in your own use of energy.

16. Participate in the political arena by supporting candidates who promote sound energy-conserving measures.

17. It has been said that an apparent objective for Canadians is to own at least one of everything. You could examine ways of sharing things that are used infrequently. Form a school consumer combine. Cutting down on the materials purchased will result in energy saving.

Usually a group can present a stronger front to its opponents than can an individual. Since politicians tend to listen more closely to large numbers of electors than to individuals, a group is more effective at bringing about environmental change. In an address entitled "Working for Environmental Change" at the Man-Environment Impact Conference, Monte Hummell, the former executive director of Pollution Probe, listed the following procedures that have been used by Pollution Probe (modified slightly):

1. Work in a consultative capacity, helping other groups to arrive at a sound solution.
2. Undertake to educate others in your school and community.
3. Sit on government committees – and influence them to make the environmentally wise decision.
4. Raise funds to promote your work.
5. Initiate legal action.
6. Do basic research on a problem and then advertise your solution.
7. Find out what studies have already been done on the type of problem you have and use them to your advantage.
8. Lobby. Go out politicking and try to sell your point of view to those who make the decisions.
9. Use the media – TV, newspapers, etc. – to promote your platform.
10. Publish material – a pamphlet, brochure, flyer, booklet, etc. – and see that the people whose opinions you wish to change receive a copy.
11. Demonstrate good conservation practices and projects to others at every opportunity.
12. Initiate local inquiries into matters of environmental concern.
13. Have personal showdowns with the opposition. Visit them and "lay it on the line".

In the coming years we will have many answers to energy problems offered at the local, provincial, and national levels of government. A good number of these will be unsound – offered for questionable reasons. We have a responsibility to challenge these. A small group can influence, change, and even stop large developments, if they take appropriate action at the right time.

> As teachers we have a very special responsibility to be more than observers, because we must try to tell others who are going to carry on after us what we see. . . . This is terribly important.
>
> From Dr. E. Pleva, "The Meaning of Habitat in the Great Lakes Region", Man-Environment Impact Conference, Toronto, November 1976.

8. Appendix: Energy and Power

To involve students profitably in the activities of this introductory part of *Energy in Society* requires only a modest understanding of the term "energy". What students have learned by Grade 7 would be sufficient. For teachers who would like their students to better appreciate the term, a very basic treatment of energy and power has been included. While it would enhance understanding of this part, it is not considered a prerequisite. However, for most subsequent parts it should be so considered.

★ Energy has been defined as "what makes things go". Power is the *rate* at which energy is converted. List at least twenty items that "go" or operate and beside each indicate the nature of the energy that makes it operate.

Some examples of forms of energy are:

1. a can full of gasoline *(chemical energy);*
2. water in a water tower (*potential* energy);
3. a moving automobile (*kinetic* energy);
4. a tubful of hot water *(heat energy).*

Other forms of energy are *sound* energy, *light* energy, and the most convenient form of all – *electrical* energy.

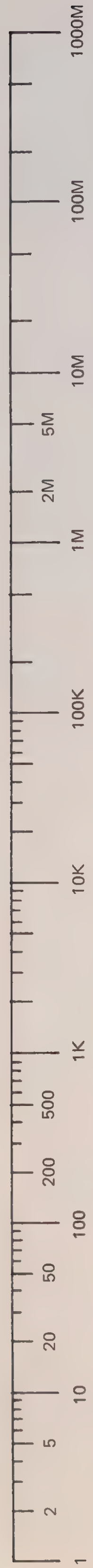
Most of the things we think of as *users* of energy are really *converters* of energy – and, unfortunately, *wasters* of energy. For example, you might buy an automobile to convert chemical energy into kinetic energy. But most of the energy (all of it in the end) is converted into heat energy, while some unwanted sound energy is also produced.

★ Make a table like this:

Table 1.7

Converters of Energy	Intended to turn ______ energy	into ______ energy	Waste Energy in the Form of ______
automobile	chemical	kinetic	heat, sound

The first example (automobile) is done for you. Other examples to try are: furnace, electric fan, nuclear power station, light bulb, oil-fired power station, car brakes, hydro-electric station, radio, ski-tow, water pump, bicycle, human body, potato plant.



Comparative Energy Potential

★ Figure 1.11 shows some typical values for the amount of energy possessed by various objects. Put them in bar-graph form. If you run into difficulty, try using the *logarithmic* scale printed at the side. (A look at a slide rule, or an electronics or audio magazine, will show you some other uses of logarithmic scales).

Figure 1.11

Item	*Amount of Energy*	*Kind of Energy*
golf ball at waist height	1 J	potential energy
curling stone moving down rink	200 J	kinetic energy
cup of coffee	2 kJ	heat energy
teaspoonful of sugar	100 kJ	chemical energy
person at top of CN tower	200 kJ	potential energy
charged car battery	2 MJ	chemical energy
1 kg hamburger	10 MJ	chemical energy
bathtub of water (hot)	15 MJ	heat energy
speeding car	60 MJ	kinetic energy
1 kg coal	200 MJ	chemical energy
tankful of gasoline	2000 MJ (or 2 GJ)	chemical energy

What Is Power?

In a hurry? To get the job done fast requires that you convert energy at a faster rate. Power is the *rate* at which you can convert energy.

Some Useful Equivalents:

Gigajoule (GJ) = 10^9 J
Gigawatt (GW) = 10^9 W

Figure 1.12

Just as	speed is the rate at which distance is covered,	so	power is the rate at which energy is used.
Just as	speed = $\frac{\text{distance covered}}{\text{time taken}}$,	so	power = $\frac{\text{energy used}}{\text{time used}}$.
Just as	a high-speed car is one that covers distance rapidly,	so	a high-powered car is one that uses energy rapidly.
Just as	speed is measured in m/s or km/h,	so	power is measured in J/s or kW. 1 J/s is called a watt (W). 1 kW is called a kilowatt (kW). 1 kW = 1 000 W 1 MW = 1 000 000 W = 1 000 kW 1 GW = 1 000 000 kW
Just as	speed x time = distance $\frac{m}{s}$ x s = m	so	power x time = energy 1 W x 1 s = 1 J $1\frac{J}{s}$ x 1s = 1 J 1 kW · s = 1000 J and 1 kW · h = 3 600 000 J = 3.6 MJ

Comparing the Power of Some Energy Converters

★ Table 1.8 shows the power of some common energy converters. Put them in bar-graph form. You may wish to add some energy converters of your own. If you are familiar with the term "horsepower", you should keep in mind that 1 HP = 746 W.

Table 1.8

Energy Converter	Power
Electronic calculator	3 W
Electric shaver	10 W
Lamp bulb	100 W
Man bicycling	500 W
Stove (Coleman)	2 kW
Stove (electric, home)	10 kW
Automobile	100 kW
Jumbo jet	200 MW
Pickering Nuclear Power Station	2000 MW
Humanity's daily conversion of energy	6 600 000 MW
Sun	3.5×10^{26} W

Calculating Power

★ It would be useful to have students complete the following table:

Table 1.9

	Energy used	Time taken	Power
1. Oven	80 000 J	40 s	
2. Frying pan	80 000 J	400 s	
3. Lawn mower	3.0 kW·h	2 h	
4. Lawn mower	0.75 kW·h	0.5 h	
5. Impala**	180 MJ*	20 min	
6. Chevette**	180 MJ*	50 min	
7. Light bulb		7 200 s	100 W***
8. Light bulb		2 h	0.1 kW***

* This is the amount of energy contained in 5L (just over a gallon).

** Convert megajoules into kilojoules and minutes into seconds before doing these questions.

*** What do you notice about these two?

Our Energy Slaves

Our use of energy to do jobs for us can be converted to the idea of having personal slaves doing these things.

A strong man can do about 2.88×10^6 J of work (2.88 MJ) in an 8 h day. If he works 365 days a year (no holidays for slaves!), he will do 1.1 GJ in total. Converted, this is 100 W or 100 J each second that he labours.

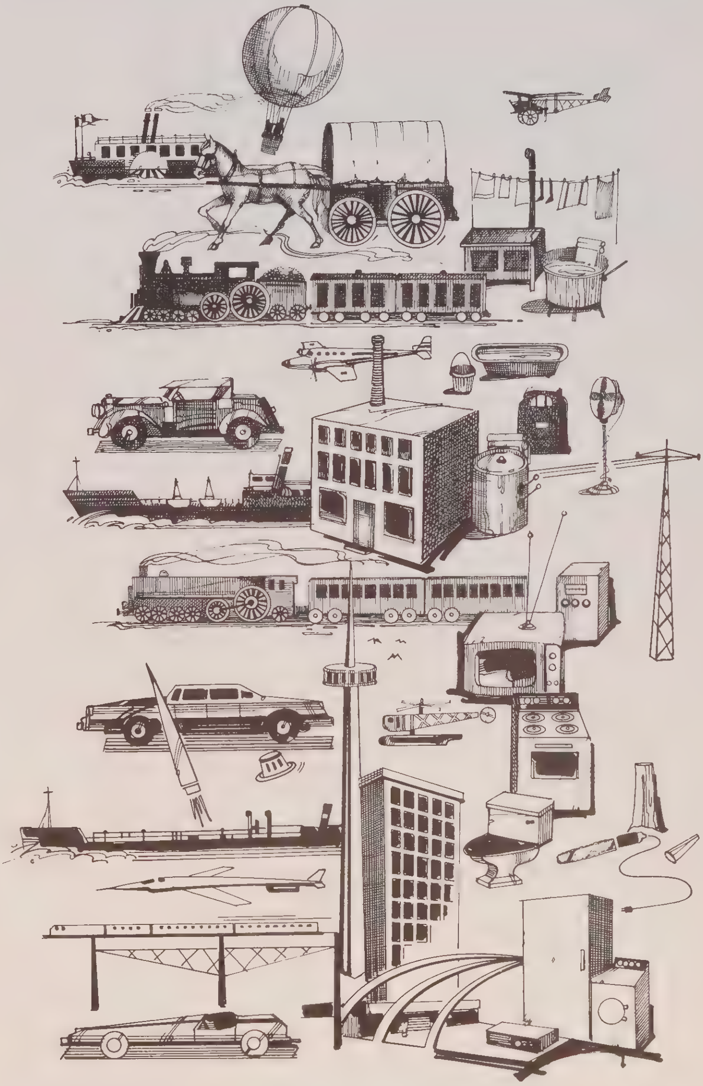
1 slave power = 100 W
= 2.88×10^6 J/d
= 1.1 GJ/a (per year)
1 slave working continuously = 100 W
= 8.64×10^6 J/d
= 3.15 GJ/a

You would need three slaves in shifts of 8 h to keep up the rate continuously.

In 1974, *each* Canadian, on the average, used approximately 400 GJ during the year. This represents *127 slaves working continuously* or about 381 slaves working in 8 h shifts!

Energy Slaves Per Capita	Years
56	1940
59	1945
64	1950
65	1955
70	1960
84	1965
101	1970
127	1975
UNKNOWN	1980

Energy Slaves



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Part 2, Space Heating

Table of Contents

Introduction 2

1. Why Heat Space? 2

2. Why Conserve Space Heat? 7

3. How to Conserve Space Heat 19

4. Conserving Space-Heat Energy – An Action Plan 29

5. Bibliography 31

★ A star beside the text indicates an investigative activity for students.

Introduction

As the daylight hours shorten and winter sets in, space-heating units operate many hours a day to maintain comfortable home temperatures. They burn enormous quantities of fossil fuels shipped or piped from the limited oil reserves of Western Canada or imported at great expense from other oil-producing countries. Collectively, we are extravagant and wasteful with the energy used in heating our homes. Such extravagance and wastefulness is unacceptable today, because the non-renewable fuels are nearing depletion. All of us should practise measures that will conserve fossil fuels and, in so doing, extend the time Canada has to find acceptable alternative energy sources.

This section deals with insulating, weatherstripping, caulking, furnace tuning, thermostat setting, and other conservation measures which, if employed by Ontario families, could reduce Ontario's total home-heat energy consumption by 30 to 40 %.

If students undertake the activities presented here, they will gain in the knowledge basic to space-heating conservation. They will also be encouraged to examine their present space-heating practices in light of their values and those held by others in the class. It is hoped that this knowledge, guided by sound values, will be applied to the improvement of their homes and, as well, to the improvement of the wider community in which they live.

This section considers four basic questions in the area of residential space heating:

1. Is it necessary from a physiological perspective to heat the space around us?
2. Do we really need to conserve the energy that is used to heat space?
3. How might we conserve space heat?
4. How might we help others conserve it?

1. Why Heat Space?

In the process of living we convert food energy to a form of energy that sustains growth and movement. Considerable heat energy is liberated in the process. As this energy leaves our cells (and ultimately our bodies), it warms our blood and, in turn, all other tissues. We cannot survive if the temperature of the body drops much below 37°C, for cell activity slows at lower temperatures and death results if the low temperatures are prolonged. To survive in our cold Ontario winters, we must ensure that the heat energy leaving our bodies is equal to that which our bodies can generate. The following activities provide opportunities to consider our bodies in terms of the heat energy they liberate to the environment around them.

What Is Your Body's Heat Requirement for Comfort?

★ This activity requires you to take a bath each night (no showers please). Prepare the bath using enough water to cover the body, at the temperature you prefer. Stay in the tub for 15 min, adding hot water as necessary in order to maintain the initial temperature. Repeat on the following nights, lowering the temperature 2°C each night, until staying in the tub becomes very uncomfortable. Record your experience in a table like table 2.1 and share your results with others who completed the activity.

Table 2.1

Recording Temperature and Bodily Reactions

Bath	Temperature	Describe How You Feel
1	$T_1 = 2°C$	
2	$T_2 = T_1 - 2°C$	
3	$T_3 = T_1 - 4°C$	
4	$T_4 = T_1 - 6°C$	
etc.	etc.	

Answer the following questions:

1. Can some withstand colder temperatures than others? If so, why?
2. Did you shiver? At what temperature? What causes shivering?
3. At what air temperature do you think you should bathe yourself to be comfortable naked?

Comfort and Air Temperature in a Temperate Climate

★ Since we are warm-blooded animals, we could survive naked only in tropical or semi-tropical areas. However, we have found ways of keeping the air in contact with our bodies at life-sustaining temperatures even though we live in a temperate climate. Describe how the air touching one's body may be kept at a comfortable temperature for the various activities occurring over a typical 24 h winter period.

Our Body Is a Space Heater

An average-sized student, working quietly at school, releases approximately 0.36 MJ of heat energy each hour. This is the amount of heat energy given off by a 100 W bulb per hour (check the calculation in figure 2.1).

Figure 2.1

Converting Watts to Joules and Megajoules

$$100\ \text{W} = 100\ \frac{\text{joules}}{\text{seconds}} = 100\ \frac{\text{J}}{\text{s}}$$

In 1 h, calculation should be:

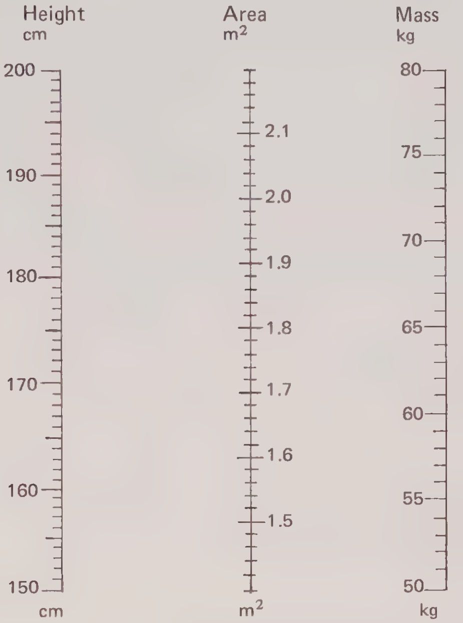
$$1\ \text{h} \times \frac{60\ \text{min}}{\text{h}} \times \frac{60\ \text{s}}{\text{min}} \times \frac{100\ \text{J}}{\text{s}} = 360\ 000\ \text{J}$$

$$= 0.36\ \text{MJ}$$

★ If a student holds one hand close to an operating 100 W bulb, and then holds one hand the same distance from his or her face, the student will notice that the bulb feels much warmer. Why does the bulb feel warmer? Calculate (or estimate) the area of the bulb. The student can determine the area of his or her body by using figure 2.2. What is the heat given off in terms of megajoules per square metre per hour [MJ/(m^2•h)] by each?

Figure 2.2

Determine Your Approximate Body Area



This is a means of approximating the surface area of your body. A line joining your height on the left-hand scale to your mass, nude, on the right-hand scale cuts the centre scale at your surface area.

How to Determine a Week's Heat-Energy Output

★ 1. Complete table 2.2 by calculating the number of megajoules per square metre per hour released by the man during each of the activities listed. Use the middle column for recording the answers.

2. The following list gives the average number of hours spent per week by a student at the activities indicated:

Sleeping	56 h
Light sedentary activities	32 h
Washing, dressing, etc.	4 h
Playing with the baby	2 h
Light domestic work	8 h
Walking	10 h
Gardening	3 h
Standing activities	7 h
Watching television	3 h
Total time spent at school, including homework	43 h

Using the numerical values given in table 2.2, determine the heat-energy output for the week if the 70 kg man spent the same hours on the activities listed. How long must a 100 W light bulb operate to release the same amount of heat energy?

3. Approximate the amount of heat your body would release during the week by expressing your mass as a fraction of the 70 kg mass of the man and multiplying it by the heat energy he releases per week.

4. Estimate the total amount of heat energy released by your classmates during a library reading period.

Table 2.2

Approximate Energy Outputs for an Adult Male 70 kg in Weight and 175 cm in Height

Activity	MJ/h	MJ $(M^2 \cdot h)$	Heat Energy Liberated by the Man (in MJ/week)
Sleeping	0.26		
Sitting quietly	0.42		
Sitting with moderate arm and leg movements (e.g., playing the piano, driving a car)	0.63		
Standing, light work at a machine or bench with mainly the arms being used	0.63		
Sitting, heavy arm and leg movements	0.76		
Standing, light work at a machine or bench, some walking about	0.74		
Walking about with moderate lifting or pushing	1.27		
Intermittent heavy lifting, pushing, or pulling (e.g., pick-and-shovel work)	1.85		
Hardest sustained work	2.32		
		Total ________	________ MJ/week

This table gives approximations for the energy output of a 70 kg adult male who is 175 cm tall. The figures can vary considerably with the physical condition of a person, his emotional state, temperature, etc. The figures give the heat energy liberated over an hour when there are no rest periods taken.

Heat Loss and Portable Classrooms

A portable classroom standing beside an elementary school is a common sight in Ontario. Some of these buildings are poorly insulated and extremely wasteful of heat energy. Example: A portable classroom measures 10 m x 10 m x 3 m. It has two average-size doors, about 4 m^2 of single-glass windows, and is built on a slab-cement foundation. On a given day with an outside temperature of −18°C, an inside temperature of 21°C, and a wind of 24 km/h, the approximate heat-energy loss in megajoules per hour (MJ/h) through the different parts of this classroom is given in table 2.3.

★ How many litres of #2 fuel oil are used per hour when the classroom is uninsulated? How many are used when it is insulated? A litre of #2 fuel oil contains 38.7 MJ (1 of 1).

What saving does the insulation bring about in terms of litres per hour of #2 fuel oil? How many students' bodies would be needed to supply the heat required to replace the heat lost per hour in the two cases? (Assume that the average heat released per student is 0.36 MJ/h.) What would be the actual amount of fuel oil saved if the furnace is operating at peak efficiency (about 75%)? You might find out how the Japanese design buildings to be heated mainly by their occupants' body heat.

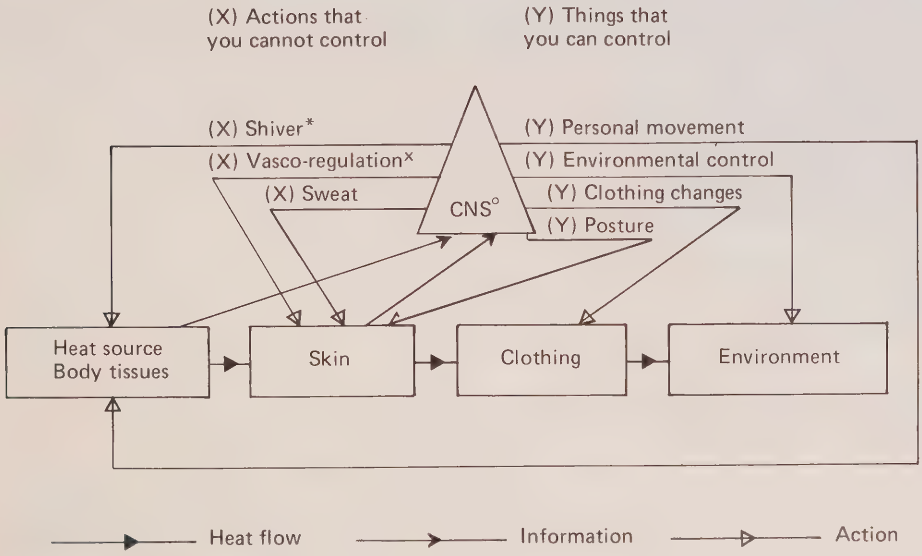
Table 2.3

Heat Energy Loss (in MJ Per Hour) From the Portable Classroom Example

Parts of Classroom	Uninsulated	Well-Insulated
Ceiling	23	1.7 (25 cm of insulation added)
Walls	25	4.4 (14 cm of insulation added)
Doors	78	2.0 (storm doors added)
Windows	47	1.2 (triple-glazed)
Floor	8	5.2 (insulated)
Total	181 MJ	14.5 MJ

1 L of #2 fuel oil contains 3.87×10^7 J.

Figure 2.3



*Shivering causes muscle movement which adds heat to the body.

×When the blood vessels constrict at the surface of our bodies, less blood reaches the surface and less heat is lost. The opposite occurs when the blood vessels dilate.

°Central nervous system

Source: J. F. Nicol and M. A. Humphreys, "Thermal Comfort as Part of a Self-Regulating System" in *Building Research and Practice,* May/June 1973, p. 175.

How Air Temperature Affects Behaviour

Figure 2.3 has many implications for the conservation of space heat. For example, as the temperature at night drops, you often change your posture to keep warm, curling up like a ball in order to reduce the heat lost through the skin. Another example is jumping up and down to warm your feet.

★ Design a series of experiments in order to determine how people react to a change in their environmental surroundings, namely a change in temperature. With the approval and support of the principal and school building superintendent, the temperature of the school could be high one day, perhaps 23°C, and then lowered on consecutive school days to perhaps 17°C. Changes of posture and clothing could be observed in a reading class over the test period. The students' comfort index could be established through a questionnaire ("much too warm", "too warm", "comfortably warm", "neither cool nor warm", "comfortably cool", "too cool", and "much too cool") at the same time. If it is not practical to change the temperature in the whole school, the experiment can be carried out in a single room.

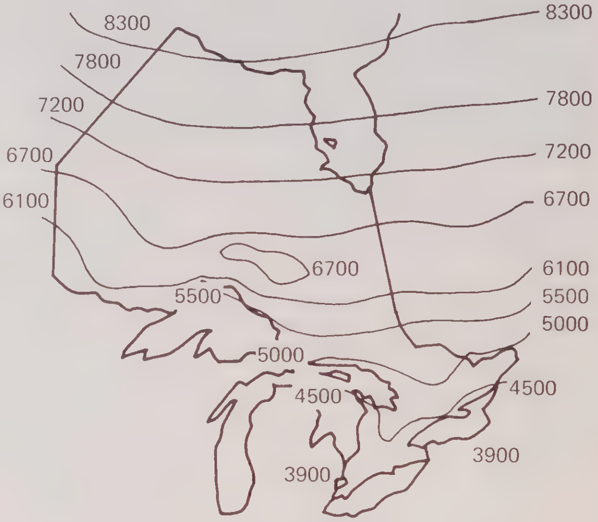
Heat Energy and Degree-Days

While clothing, body movement, and posture may affect body temperature, they are not, in themselves, sufficient for survival in our Ontario winter. Heating the space outside our clothing and within the shell of buildings is necessary. This space requires, over a heating season, the addition of heat energy in proportion to the coldness of the region of Ontario in which the building is located.

Heating engineers use a unit called a degree-day to measure the coldness of a geographical area and hence its fuel requirements. The number of degree-days in a calendar day is determined by subtracting the day's average temperature from 18°C. If the high on a given day was 15°C and the low was 4°C, the average temperature that day would be 10°C. This average subtracted from 18°C would give 8 degree-days for that calendar day. No degree-days are counted when the mean temperature is above 18°C. The amount of energy required to keep the interior of your residence at about 21°C,when the outside air temperature is below 18°C, is roughly proportional to the difference between 18°C and the outside temperature. This measure assumes that no heat is required when the average outside temperature for the day is 18°C or higher. The data for table 2.4 and figure 2.4 (figures used are approximations) are supplied by meteorological records. The symbol for degree-day(s) is °C•d when used after a numeral.

Figure 2.4

Ontario Degree-Days



Comparing Energy Consumption in Different Ontario Locations

The amount of heat energy required to keep a house comfortable is roughly proportional to the annual number of degree-days in its area.

★ If a given house used 1.0 TJ (terajoules) of energy annually in Windsor, how much more, approximately, would it use in Toronto, Moosonee, Ottawa, Kapuskasing, or Huntsville?

Table 2.4

Approximate Degree-Days
(°C•day)
(Accurate records can be obtained from your local meteorological office.)

Location	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Yearly Total
Huntsville	28	57	130	320	520	780	860	770	690	420	210	65	4800
Kapuskasing	74	110	240	410	670	1000	1100	960	850	520	320	140	6400
Moosonee	98	120	250	450	710	1040	1200	1000	940	620	400	190	7000
Ottawa	11	30	130	300	510	800	900	780	660	380	190	47	4700
Toronto	4	9	78	220	420	620	700	620	550	330	170	36	3800
Windsor	3	9	70	210	420	620	700	610	526	300	150	31	3600

Calculating Fuel Oil Delivery

★ You live in the Ottawa area and have an average heating-fuel consumption over the past six years of 5000 L/a (litres per annum). Your fuel tank has a capacity of 900 L. It was filled on July 1.

1. If 200 L of oil is a safe margin to have continually in your tank, calculate the number of deliveries and suitable dates when the tank should be filled over the year. (Use table 2.4.)
2. If the burner nozzle on your furnace is rated at 5.0 L/h flow, for how many hours would the burner motor operate during the season?
3. What would be the cost during the season in electrical energy if the burner motor draws 12 A on a 115 V circuit? Refer to part 4 on electricity and energy if necessary.
4. Calculate the number of deliveries and suitable dates for them for your Ontario location, assuming that your fuel consumption is 4000 L/a and your tank capacity is 700 L.

Heat and Bodily Reactions

★ To be exposed to cold and to survive exposure is a gruelling challenge for the human body. Use the library to find information for a report on how the human body reacts when it is plunged naked into a temperature below freezing. Include in your report information on the hypothalamus and its function, the receptors in the skin, blood-vessel constriction, heart action, involuntary muscle action (shivering), and internal-heat production. You might like to consider the opposite situation as well: how we react physiologically to high temperatures.

2. Why Conserve Space Heat?

Are we really running out of oil and natural gas? How serious is the shortage of these fossil fuels? Do we need to change our life style? This section considers these questions. Reference is made to Federal Government predictions regarding Canada's energy demand and supply. Some of the techniques associated with values education are employed, offering students the opportunity to examine and clarify the values they presently hold towards home-heating practices.

How Concerned Are People About Dwindling Energy Resources?

Since 88% of all Canadians heat their homes with either gas or oil, using enormous quantities of both in the process, space-heating conservation measures are necessary. However, many Canadians doubt either their ability to reduce their use of fossil fuels or the necessity for doing so. Others believe that the world's dwindling supply of fossil fuels makes conservation measures essential. How do you feel about this? Can you personally contribute to conservation?

★ Indicate your personal opinion by placing an "X" on a values continuum such as figure 2.5, having as one extreme *"There is nothing I can do. I'm not concerned. My goal is zero saving,"* and the other extreme *"There is a great deal I can do. I'm very concerned. My goal is to save 50%."* List the reasons for your position on the continuum and share these reasons with others in your class or group.

When you have completed your study of "Space Heating – Energy for Living Semi-Tropically", repeat this activity.

The Oil Age: A Drop in the Bucket?

To most of us, "a long time ago" is measured in tens of years. We may remember the life style of our grandparents or even of our great grandparents. To think in terms of thousands of years is not easy for most people. It is necessary, however, in considering the fossil-fuel era.

The human era on earth – supposedly one million years – can be used as a point of reference for the life of one of the rapidly depleting, non-renewable fuels – oil. In 1857, a small hand-dug well in Ontario produced the first oil in Canada. We can say, therefore, that our oil age to date has lasted 120 years. If the human era is represented as a line of 25 m, the oil age is equal to 3.0 mm. Another 40 years of oil production, if there is that much, adds another millimetre on the scale.

★ Take a ball of string or a hank of rope and run out 25 m around the classroom; measure off 4.0 mm from the end and mark this portion with masking tape. You now have a measure of the significance of the oil age in the perspective of a human evolutionary scale.

List six questions that occur to you after doing this demonstration. Discuss possible answers to these questions. Should we be concerned about the depletion of our oil resources?

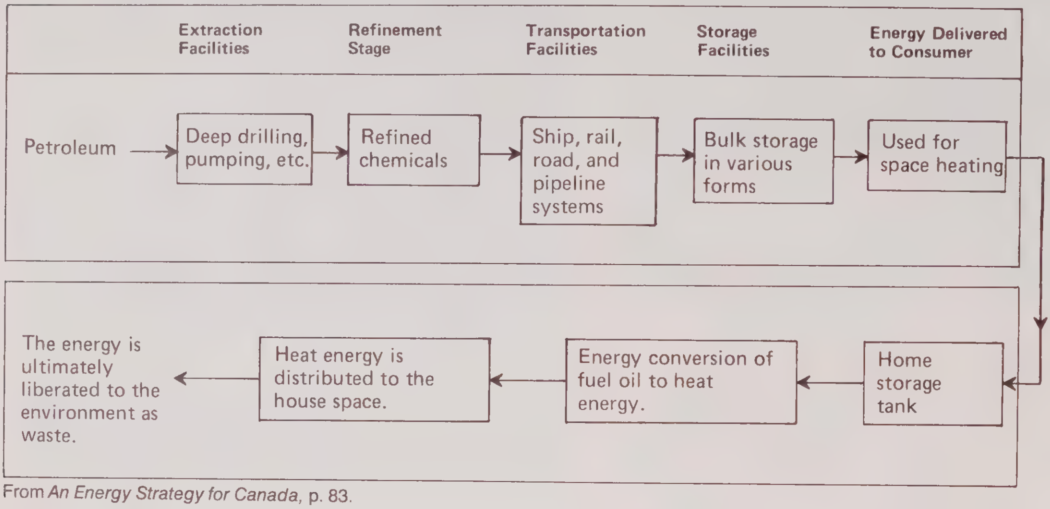
Figure 2.5

The World's Dwindling Supply of Fossil Fuels: A Values Continuum

Place an "X" on the line to indicate your position.

Figure 2.6

Petroleum—Space-Heating Energy System


Extraction Facilities
Refinement Stage
Transportation Facilities
Storage Facilities
Energy Delivered to Consumer
Petroleum
Deep drilling, pumping, etc.
Refined chemicals
Ship, rail, road, and pipeline systems
Bulk storage in various forms
Used for space heating
Home storage tank
Energy conversion of fuel oil to heat energy.
Heat energy is distributed to the house space.
The energy is ultimately liberated to the environment as waste.

From *An Energy Strategy for Canada*, p. 83.

From Crude Oil to the Atmosphere Around Your Home

★ List the various processes of the petroleum – space-heating energy system as shown in figure 2.6. Beside each process (transportation, refining, etc.), indicate how the process in itself converts energy-rich materials to low-grade waste heat energy. If your oil-fired furnace is 60% efficient for every 60 energy units converted to space heat, how many are wasted? What is the total system efficiency?* In light of this, discuss the statement "You do not get something for nothing."

Looking at Oil's Future Supply and Demand

★ Figures 2.7 and 2.8 are forecasts of our future domestic demand for and availability of oil. Figure 2.7 assumes that Canadian oil prices will remain low in relation to international prices and figure 2.8 assumes that the price will rise until it equals (by 1979) the international price. The extra money brought in would be used in part by the oil companies for exploration and development of new oil sources.

1. From figure 2.7 or 2.8, estimate how many barrels of oil per day can be produced in 1990 from the presently known reserves – the only sure source.

2. How many barrels of oil per day will be required in 1990? Why is more oil required in the low-price forecast?

3. How many barrels of oil per day would have to be imported into Canada in 1990 according to each forecast? Where would the oil likely come from?

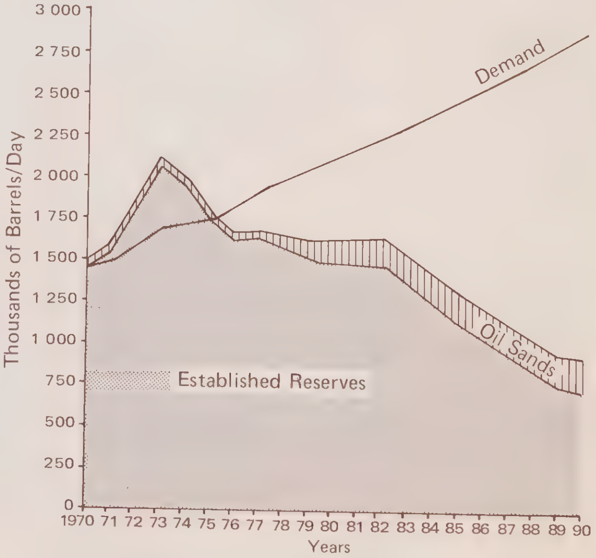
4. If the international price for a barrel of crude oil is $25 in 1990, estimate how much money Canada would spend for oil during the year 1990 under each forecast. How much less would be spent by Canada in 1990 if oil prices are allowed to reach international levels?

5. Discuss the possibility of Canada's becoming dependent on outside oil suppliers. If Canada could export Cadillacs to the Organization of Petroleum Exporting Countries in exchange for the oil imported, how many Cadillacs would be required during 1990 at a cost of $20 000 for each car and $20 for each barrel of oil?

6. Examine table 2.5. How many barrels of oil per day would be available in 1990 from the oil sands for each forecast? What accounts for the difference in each forecast?

Figure 2.7

Domestic demand and availability: oil (1970-1990; low-price forecast)



Source: Department of Energy, Mines and Resources, *An Energy Strategy for Canada* (Ottawa: Publishing Centre, Supply and Services Canada, 1976), p. 75.

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* It has been estimated that for every 100 L of fuel oil delivered to our homes, the equivalent of another 13 L have been required to power the various processes required before the refined oil reaches our tanks.

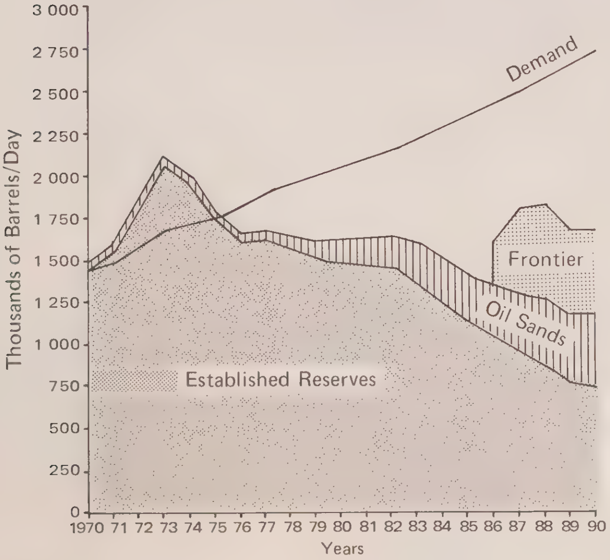
Table 2.5

Comparison of Possible Future Sources of Canadian Domestic Petroleum

Source	Comment
Established areas	Very few discoveries are expected in the present production areas of Western Canada.
Enhanced recovery techniques in established areas	It is expected that these will be expensive and time-consuming and will contribute little to meeting our needs.
Frontier areas: 1. Atlantic and Eastern off-shore areas	• Reserves have yet to be found; • the technology to enable operation in ice-bound waters has yet to be developed; and • an adequate transportation system to take the crude oil to the market does not exist.
2. Northern Regions — in particular the Western Arctic	This is the most promising area. Its future depends on money being available for exploration and development. To bring this crude oil to market depends on our having an environmentally acceptable transportation system. Solutions would have to be found to problems such as native rights, the renting of land, and foreign ownership.
Oil sands	Enormous amounts of oil are locked into the sand. Present technology is expensive in dollars ($1 billion per 125 000-barrels-per-day output) and in energy (23 units of energy are required to produce 100 units of oil as opposed to 4 to 7 units of energy expenditure per 100 units of conventionally produced oil).

Figure 2.8

Domestic demand and availability: oil (1970-1990; high-price forecast)



Source: Department of Energy, Mines and Resources, *An Energy Strategy for Canada* (Ottawa: Publishing Centre, Supply and Services Canada, 1976), p. 82.

The Cost of Delivering Oil to the Consumer

★ Future Canadian domestic oil will cost much more in terms of the energy required to bring it to the consumer. By referring to the petroleum – space-heating energy system (figure 2.6) and table 2.5, explain why more than the present average of 13 units of energy will probably be required to bring 100 units of fuel to our homes in the future.

Can Fossil Fuels Be Recycled?

The winter-long efficiency of most Ontario furnaces is between 50 and 60%. This means that for every 100 units of potential heat energy in each litre of fuel oil delivered to a residence, only 50 to 60 of the energy units are transformed into heat units in the space of a residence. This loss results partly from the inability of a furnace burner to convert the energy in fuel oil to heat energy, partly because of burner efficiency and design, partly because of poor mechanical adjustment of the furnace, and partly because of the escape of heat up the chimney and into the basement.

★ What ultimately becomes of the heat energy contained in fossil fuels used for space heating? Discuss the statement "Fossil fuels used for space heating cannot be recycled; once used, they are gone forever."

How Do You Change a National Mind Set?

> What are some of the things Canadians have to do to change a national mind set which burns everything with utter profligacy to one which has some kind of conserving and cautious approach to the management of depleting resources?
>
> Mr. A. Shepherd, Executive Director, Science Council of Canada, December 1976.

★Discuss this statement in terms of fossil fuels.

Energy Use in Heating and Cooling

After the oil-price increase of 1973, the following studies were undertaken. The figures given are based on actual measurements. Energy-consumption figures include air conditioning in summer.

Table 2.6

Facilities	*Annual energy consumption per square metre*
Ontario Hydro Survey of 80 office buildings in Toronto	15 MJ
Ontario Hydro Survey (newer buildings only)	18 MJ
Ontario Hydro Survey (hotels)	20 MJ
B.C. Hydro Survey of 25 office buildings in Vancouver	21 MJ
Survey of Federal buildings	29 MJ
Engineering *estimates*	
wholesale and retail trade	20 MJ
education facilities	13 MJ

★ The spectacular increase in indoor shopping malls has been a recent Canadian phenomenon. A mall area turns our frigid Canadian winter into a semi-tropical climate enabling customers to stroll coatless from one store to another. Estimating the floor area of a local mall and the approximate amount of energy used over a year is a challenging exercise for students. Try it.

★ 1. If there are 300 malls in Ontario of approximately the same size as your local one, how much energy would be consumed by them annually? What would this be in litres of fuel oil? How do you feel about this particular use of fossil fuels? Remember that without malls stores would have exposed fronts and doors opening directly to the outside.

★2. List locations – commercial or residential – where you feel that a large amount of space is being heated unnecessarily. Use the above figures to estimate the quantity of energy wasted.

Cutting Canadian Oil Consumption

Reasons for Ontario residents to conserve energy used for space heating have been presented in recent Federal Government publications. Almost all of us believe in conservation to some degree. For some people, it is a simple matter of saving money; for others, a husbanding of resources now to prevent future shortages. For yet other people, conservation represents an ideal, a way of life.

★1. Analyse these three ways of considering the energy crisis and compare them with your own viewpoint.

★2. Work out the following problems: (a) How many barrels of oil would be saved during 1985, if Canada cut back consumption by 10%? (b) At $15 per barrel, what sum of money would be kept from leaving the country? (See figures 2.7 and 2.8. Work this out for each forecast.)

Can We Force More Realistic Thinking?

It has been suggested that people will only conserve fuel if the price is much higher than it is now. Price increases set by the Organization of Petroleum Exporting Countries have had some shock effect on the world, but the last few years have shown that the world has not been sufficiently shocked to change its oil-extravagant ways. It is likely that the world prices of oil will continue to rise.

★ Some people feel that the Canadian government should raise the price of fuel oil so much that people will be forced to adopt good space-heating practices. The cost of insulation and storm doors would be soon repaid in terms of fuel oil saved. Debate this and the following statements:

1. The Canadian government should take direct action and deliberately seek lower rates of heat energy usage through regulation and mandatory controls; otherwise the collective savings in a community will be insignificant.

2. People in the community will want to conserve, once they know the seriousness of the energy situation. More accurate information about the problem and procedures on how to conserve are all that is necessary.

Canada's Northern Gas Resources: Is There an Acceptable Solution?

★Canada's reserves of natural gas are nearing depletion and can no longer satisfy Canadian residential and industrial needs. It has been established that there are proven supplies of natural gas in the Canadian Mackenzie River Delta sufficient to meet Canadian needs at the present rate of use for nine years; optimistic estimates place potential reserves at fifty more years. Nearby in Alaska, larger proven supplies have been found, and estimates of further supplies are extremely encouraging. Discuss such questions as:

1. Is it desirable to bring this natural gas out of the Arctic?

2. What would be the effects on the natural environment? On the lives of the native peoples? On Canadian relations with the United States?

★The following proposals and viewpoints describe key issues associated with removing frontier-area gas for southern markets. Analyse the issues and related arguments, identifying bias and answering the following questions:

1. Do you feel that any of the people involved would have an unbiased opinion? Discuss your feelings.

2. Whose position do you feel you can back best? Why?

3. Do you accept Maurice Strong's point of view? Why?

Proposal #1 Made by X Limited

A group of major oil companies have formed a group called X Limited which proposes a 4200 km gas-carrying pipeline through Canada from the Mackenzie River Delta. It would be joined by a pipeline from the American gas fields in Alaska. This pipeline would run through the Northwest Territories into Alberta almost to Calgary where it would split, with one branch going into the United States via British Columbia and the other swinging into central Canada.

The Canadian National Energy Board: A Simulation (see p. 14)
In each case, give reasoned arguments supporting your position.

1 You are an Inuit, fifty years of age, and proud of the fact that your ancestors have hunted in the Mackenzie River valley for 6000 years. The proposed pipeline will pass through your hunting area. You don't want this.	2 You are two lawyers representing the Inuit. The Inuit have never entered into agreements with the Federal Government over land use. They have never signed their land away and have aboriginal rights, as well as moral rights.	3 You represent three specialists in the areas of water, plant ecology, animal ecology, and air pollution respectively. You present reasons why any large development in the North would have a great negative effect on the environment.	3 You are representatives from the Association of Petroleum Pipeline Engineers. Your studies indicate that a pipeline could be built that is "environmentally safe".
2 One of you is president of X Limited and the other of Y Limited. You are both engaged in a conversation with the N.E.B. chairman, and it turns into an informal debate between the two of you over the merits of an all-Canadian pipeline.	2 You represent a large group of scientists who believe that the billions to be spent on a pipeline should be spent on developing alternative sources of energy such as solar and wind.	1 You are the president of X Limited. You are presenting the advantages of your group's proposal as well as the disadvantages of Y Limited's proposal.	1 You are the president of Y Limited. You are presenting the advantages of your group's proposal as well as the disadvantages of X Limited's proposal.
2 You are president of a large factory located in a town in Southern Ontario and are accompanied by the mayor of the town. If your factory cannot be assured of ample gas for the next fifteen years, then you will need to start closing the plant down. If so, 30% of the townspeople would lose their jobs.	3 You are a group of business people (realtor, snowmobile dealer, restaurant owner, land developer) who, a few years back, moved north in anticipation of great development. You present reasons why the North should be opened up.	1 You are the owner of a snowmobile factory located in Southern Ontario. If 30% of the anticipated people associated with building a pipeline were to buy snowmobiles for use in the North for hunting and fishing along the Mackenzie River, your factory would have it made.	2 You are environmentalists who are concerned about the impact of the snowmobile on the delicate tundra. You have evidence showing how destructive they can be to the ecology.
3 You are a group of young Inuit who have lived for a number of years in the South and reject the South's life style. You wish to live a life in tune with your natural environment as did your ancestors. You feel that this is a better way of life and you do not want it lost.	3 You are directors of X Limited. You are presenting reasons why maintenance of energy in the form of natural gas is necessary, if the stability of Canada's economy is to be maintained. This would justify pipeline construction in spite of all the objections.	1 You are a world-renowned environmentalist who believes that the quality of life is not dependent on the amount of goods that are produced. The availability of lots of things made from the North's energy does not ensure a better life.	3 You represent an Inuit town council of a town that would grow almost overnight from 500 to 5000 people if the pipeline were to be built. Since almost all of the newcomers would be single men, there is much concern about the effect this would have on family life. You anticipate unhappy results and give examples of negative things that have happened elsewhere under similar circumstances.

The president of X Limited argues that partnership with American companies makes good sense, since the present proven reserves in Canada do not economically justify building a pipeline at the estimated cost of $7 billion. If the Alaska gas is also carried by it, then it will be economically sound. The president estimates that the United States would pay Canada for the pipeline an annual rent of half a billion dollars. He is confident that proven reserves will be discovered in Canada, making an all-Canadian pipeline feasible. Such reserves do not exist now, however, and it could be years before the pipeline would be started. His group could start immediately. They would use a large pipe (1.22 m in diameter) that would handle a large gas volume at lower per-unit costs of transportation. His group has already spent hundreds of millions of dollars in exploration and in developing the technology necessary for an environmentally acceptable pipeline.

Proposal #2 Made by Y Limited

A Canadian consortium has been formed which we will call "Y Limited". The president believes that the existence of proven gas reserves in Canada and the potential for other reserves merits an all-Canadian pipeline. Since it would not carry American gas, it could be smaller in diameter (1.02 m) and hence easier to install. This pipeline would be financed by Canadian sources. Canadians would own it. Canada would not run the risk of being manipulated and controlled by the United States.

Proposal #3 Made by Ms. Dawson (Federal Ministry of Transport)

Ms. Dawson is the representative of the Federal Ministry of Transport. Her assistants have considered alternative means of moving the natural gas. These include giant cargo planes, tankers down the coast, and an Arctic railroad. Engineering studies indicate that a railroad would work. A railroad into the North would offer a much greater potential for development of the North than would a pipeline. As Ms. Dawson often points out, "If we spend more than a billion dollars for a pipeline and we do not have the reserves, then what good will it be? A railroad could move people and materials as well as gas." She acknowledges that a railroad would take at least three times as long to build as the pipeline. Also, the gas would have to be liquified for shipment, and this would require a considerably greater energy expenditure than would the pipeline (18% as opposed to 9%).

A Point of View: Anna Anishinabi (Native Person)

Anna Anishinabi is a Northerner, an environmentalist, and a member of the Native Council of Canada. She speaks eloquently of the concerns of Northerners and of her fear that the land in which her ancestors have lived successfully for thousands of years will be destroyed. She feels that the proposed pipeline would hinder the migration of the caribou and ultimately lead to their extinction, and that it would disturb the spawning of fish and the nesting of waterfowl. She feels that the vegetation that has formed over many thousands of years in the cold North would be destroyed by the movement of the army of men and machines necessary for construction of the pipeline. She points out that there is still debate about such things as the amount of damage resulting from the use of winter roads, with heavy damage to vegetation and considerably increased thawing and pooling of water. Waste disposal is another recognized and unsolved major problem in the North, and, with so many people in different areas, it would be impossible to maintain the surveillance required. She sees the pollution of fresh water and the poisoning of air as has been the case in several northern mining towns. "There may be room for this kind of thing in your definition of the good life but not in ours." She is concerned that white men will move in from the South and disrupt native family life. She is certain that if a pipeline or a railroad were allowed, she would live to see her land destroyed for the questionable purpose of extending the time period that Southerners may be able to enjoy their present energy-wasteful life style.

A Second Point of View

Oil company engineers have made the following claims:

1. We have been able to plan a route that will minimize any disturbances to plants and animals.

2. We have found a way to lower the temperature of the gas to below freezing before we pipe it. In this way it will not melt the permafrost nor harm the vegetation.

3. There are 35 000 people living in an area of 3.8×10^6 km^2 and the proposed pipeline would take up only 102 km^2. The native people would have adequate land on which to live if the pipeline were to be constructed.

4. We will bury the pipe for its entire length and then carry out a program of revegetation to restore the surface.

5. We will initiate a program of recruiting and training of Northerners so that they may participate in building the line and benefit from the job opportunities.

6. Through test programs and trail studies we now have the technology to build the special plants, compressor stations, and in general to carry out this colossal undertaking.

7. We cannot afford to wait since our projections indicate that Canada will need fourteen times the present reserves over the next twenty years, and we know that we will find the gas in the North.

A Third and Somewhat Contrasting Point of View

> It is unfortunate that larger-scale northern development is now beginning, because I believe we do not yet know enough about the Canadian North and its peoples to manage development wisely. Seriously limited knowledge of the northern ecosystems, combined with a relentless appetite for new energy and new development can be a mixture fraught with danger for the future of this important part of Canada and its peoples.
>
> Heedless destruction of northern game habitat and northern game will mean either the destruction of large numbers of native people or else their reduction to complete dependence on food shipped in from outside, provided it can reach these isolated communities (an enormously costly prospect). Would we dare call it "progress" to reduce an independent and well-adapted people to the position of living as strangers in their own land – strangers who must be fed from the outside?
>
> To me, the preservation of an independent and well-adapted people, the protection of a fragile and harshly beautiful environment, and the maintenance of the indispensable flora and fauna seems sensible. I fear, however, that for those whose principal obsession is with Canada's energy needs and who assess energy in accordance with plans for needless expansion – development for the sake of development – the foregoing will seem like a sentimental indulgence which Canada cannot afford. Have we not already heard some who claim that the welfare of the majority must take precedence over the selfish claims of the minority?
>
> From Maurice F. Strong, "Northern Energy: A Fragile Giant", Man-Environment Impact Conference, Toronto, November 1976.

The Canadian National Energy Board: A Simulation

Assume that a large industrial group desires to build a gas pipeline along a river valley in Canada's far North. Before this group or any other organization or individual can proceed with any energy-related construction, approval from the National Energy Board is required. The N.E.B. will hold hearings at which environmentalists, oil companies, provincial governments, industrialists, and any other interested person or group might offer their points of view. On the basis of these hearings the N.E.B. will make recommendations as to whether or not construction should proceed.

To assist with this simulation activity, students will be provided with a quantity of cards to be used in a discussion format. Each of the cards describes a point of view. The cards should be pasted on cardboard, cut out, and placed in a pile face down. To initiate the simulation, a student will pick a card. If the card chosen has a "one" on it, the student must do an individual improvisation. If it has a "two", the student will improvise with someone from the class whom he/she has selected; if a "three", the student will work with two others whom he/she has selected. Cards should be picked until everyone in the class has a part. The students can decide whether they want to have time to prepare their presentations or whether they wish to make them impromptu. Following each improvisation, the class should discuss how well the participants played their roles; how effective they made their points; and, assuming that it is a presentation made before the N.E.B., the likely recommendations that this body would make.

The Northern Oil Reserves and the Implications of Exploiting Them for Energy

★ In preparation for this study, clip newspaper items about the following issues: northern oil reserves; the environment; rights of native peoples; national sovereignty; regional priorities; and government regulations. Sort the clippings by issue and by viewpoint. Statements by oil-company executives, Federal cabinet ministers, and leaders of native people would go in different categories.

Identify conflicts and check for accuracy. For example, suppose that an oil-company executive promised that the environment would not suffer from a proposed pipeline and an Eskimo leader predicted the exact reverse. As stated here, both statements are invalid because neither one offers any proof; both cannot be true. Either discard unproved statements or research the question yourself and decide on the accuracy through class debate. Sometimes, a current newspaper clipping will throw some light on the question. Discuss which sources are reliable and up-to-date.

It is also possible that two conflicting statements could both be true. For example, one speaker might say "Southern Canada needs the oil." Another might counter: "The environment and the life pattern of the native peoples will suffer."

(Adapted from Conserve Energy, by permission of Ontario Hydro)

Play Conserve Heat Energy at School and at Home

(Adapted from *Conserve Energy*, by permission of Ontario Hydro)

"Conserve Heat Energy" is a conservation game for the entire class or for the entire family, from age five to adult. It's easy to play, yet provides an ideal medium for learning the basics of heat-energy conservation in the home . . . and it's fun! The rules of the game, drawcards, and a complete playing surface follow. All that is required is a die, and if one is not available, you can manufacture your own by placing dots on a sugar cube. To increase the durability of the game, it is recommended that the playing surface and the drawcards be glued to light cardboard. The drawcards should then be cut out. Four or five people may play on each board.

Rules

1. Each card has either a good heat-conservation measure or a poor one marked on it. As a player group, decide whether each card represents a good measure or a poor one, and on this basis separate them into two piles.

2. Together, rank-order the cards in the good-measures pile by considering how much each one contributes to conserving heat energy. As a group of players, place a value on this in the following way. If you feel it to be a minor saving, mark in pencil "advance 1", or if a major saving, mark "advance 8". Two or more cards may be given the same value. In your ranking, try to use all the numbers from 1 to 8.

3. Together, rank-order the cards representing poor practices by marking in pencil "Go Back 1", or "6", or "8", or whatever you feel appropriate. In your ranking, try to use all the numbers from 1 to 8.

4. Shuffle all the cards together and place them face down on the table.

5. Use paper clips or coins of different sizes as counters. To begin, all players must place their counters on the start arrow.

6. Use one die only. Each player shakes the die in turn, moving clockwise. The highest number begins the game. To move onto the board a player must roll a six.

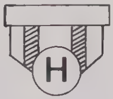
7. After rolling a six, each piece moves according to the number shown on the die.

8. After landing on a rectangle marked "Drawcard", the player must pick up the top card and move according to the value assigned to it. For example, a player landing on the rectangle marked "4" and drawing a card marked "advance 5" will move to rectangle "9". If a player must return to the start, he or she must again roll a six before advancing onto the playing surface. When a card has been drawn, place it in another pile face up. When all cards have been drawn, shuffle and place face down.

The first player to land his or her counter on the "Energy Medal – Congratulations" square "90" is declared the winner. However, this player must roll the exact number to win. For example, a player on "88" must roll exactly two to win, a player on "89" will need a throw of one. . . . After a winner has been declared, the other players may continue to play to decide second or third placings.

Two or more playing pieces may occupy a single square without penalty.

Conserve Heat Energy

82	DRAW A CARD	84	DRAW A CARD	86	87	88	89	Energy Medal  Congratulations		
81	80	79	78	DRAW A CARD	76	75	DRAW A CARD	73	72	
DRAW A CARD	63	64	Front door left open — heat escapes. Go back 4.	66	67	68	69	DRAW A CARD	71	
61	60	59	58	57	56	DRAW A CARD	54	DRAW A CARD	52	51
41	42	DRAW A CARD	44	45	46	You keep a proper relative humidity. Advance 3.	48	49	50	
DRAW A CARD	39	38	37	Cleaned your furnace filter. Advance 4.	35	34	33	DRAW A CARD	31	
20	21	22	23	DRAW A CARD	25	26	DRAW A CARD	28	29	30
DRAW A CARD	18	17	16	15	14	13	DRAW A CARD	11	10	
START	1	2	3	DRAW A CARD	5	Too lazy to put on your storm windows and doors. Go back 6.	DRAW A CARD	8	9	

Drawcards

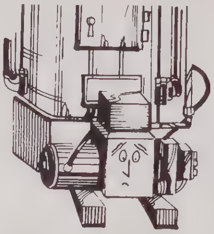
You have a windbreak planting.

Go back
Advance

windbreak planting

You don't change the air filters on your furnace regularly.

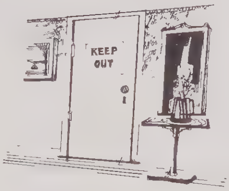
Go back
Advance



filters not changed

You have closed off the spare room.

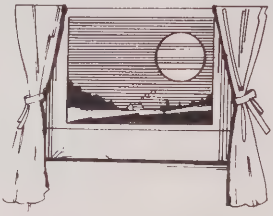
Go back
Advance



spare room closed

You don't close the drapes at night.

Go back
Advance



drapes not closed at night

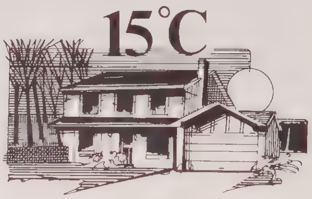
You have put on storm windows (or double or triple glazing).

Go back
Advance

storm windows

You have a thermostat night-time setting of 15°C.

Go back
Advance



night temperature

You have caulked around window and door frames.

Go back
Advance

caulking

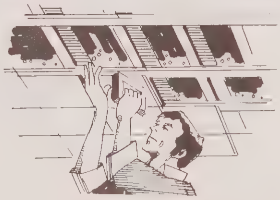
You set your daytime temperature at 20°C.

Go back
Advance

day temperature

You have insulated the side and bottom of a crawl space.

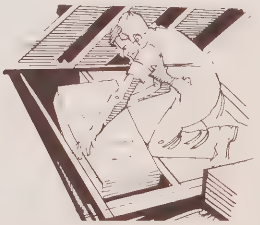
Go back
Advance



crawl space insulated

You have R_{20} insulation in your attic.

Go back
Advance



R_{20} insulation in attic

Your warm clothing permits you to set your thermostat lower.

Go back
Advance

warm clothing

You have R_{12} insulation in your basement.

Go back
Advance

R_{12} insulation in basement

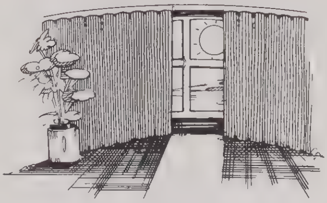
Your fireplace damper has been left open.

Go back
Advance

fireplace damper open

In winter you keep the drapes closed on sunny days on windows facing south.

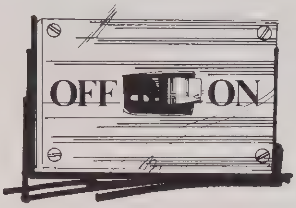
Go back
Advance



drapes closed on sunny days

You left the exhaust fans on in the kitchen and bathroom.

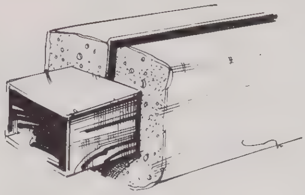
Go back
Advance



exhaust fan left on

The heating ducts in your cool basement are insulated.

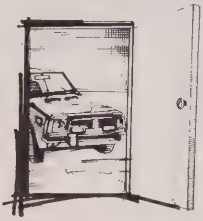
Go back
Advance



insulated ducts

You left the door open to the attached garage.

Go back
Advance



door to garage open

You have not had your furnace serviced and adjusted this year.

Go back
Advance

furnace not serviced

Your outside doors are not weatherstripped.

Go back
Advance

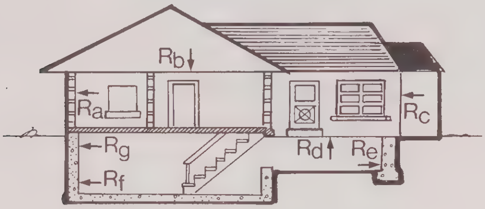
outside door not weatherstripped

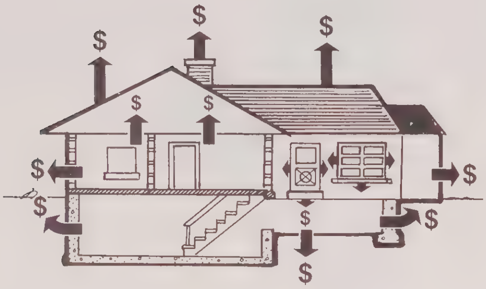
Conserving Space Heat: Basic Data

Heat energy always moves from a warm region to a colder one. In the winter, this means that the heat energy produced in our furnaces sooner or later escapes to the outside to "heat the sky". The heat moves outward in three ways – through conduction, convection, and radiation. Since any unnecessary loss means wasted heating-fuel dollars, the purpose of insulation is to slow down the escape of the energy. The better our insulation, the longer the heat energy is retained and the less heating costs are incurred.

"R" represents Thermal Resistance value. The higher the "R" number, the greater is the ability of a material to resist the escape of heat energy.

It is strongly recommended that the calculations included in the following activities be done carefully and discussed fully.





Both the houses illustrated on this page, and those in table 2.7 are of standard frame construction. All of the calculations in the accompanying graphs are based on an outside temperature of -18°C, inside temperature of 21°C, attic temperature of -12°C, and a wind blowing at 24 km/h.

★1. Examine each graph carefully. Discuss the value of insulation, storm doors, and storm windows. Calculate the energy lost per square metre per hour (MJ/m^2/h) for the top bar in each. Enter your calculations in table 2.8 starting with the building structure (window, wall, etc.) having the greatest loss of energy per square metre per hour. The calculations in this activity on heat loss in an uninsulated house should be repeated using data from the second bar in each graph. Compare your results with the first set of calculations.

2. Calculate the heat lost per hour for each structure in the bungalow and two-storey house described in table 2.7. What is the total heat loss in the living area per hour from each? Express the heat lost from each part of the bungalow or two-storey house as a per cent of the total heat lost per hour. Which house requires more heat energy? Both houses have the same living area. Which one requires the greater amount of fuel to maintain it at 21°C? Why?

3. Since neither the bungalow nor the two-storey house described (table 2.7) have front storm doors, approximately $20 worth of heat energy will be lost from each door during this heating season.

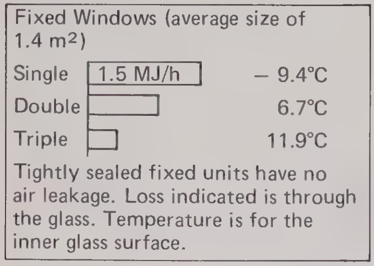
A good storm door would cost about $100 if you installed it yourself. How much money would you save this season? If fuel prices remain constant, how long would it take to recoup the expense? How long would it take if fuel prices double next year?

4. This heating season, the bungalow will lose $210 worth of heat energy through the attic. If you were to insulate to an R factor of 7, what would you save in terms of heat-energy dollars? What would it cost to insulate the attic to R7 if it costs 8¢/m^2 for each factor of 1? How long would it take to recoup this amount at today's fuel prices?

5. How much more would it cost to insulate the attic of the bungalow from R7 to R28? Approximately how much would you save during this heating season? Why would it be a questionable dollar investment to insulate from R28 to R35?

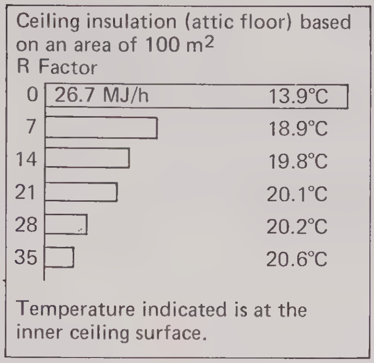
6. One of the drawings on this page has an "R" at different locations. Each arrow touches an area of the building that should be insulated, however, the R value has not been given. What do you think the R value should be for each? The recommendations of the Federal Office of Energy Conservation for minimum insulation factors (R values) can be obtained from insulation contractors to check the accuracy of your estimates.

Figure 2.9


Fixed Windows (average size of 1.4 m^2)

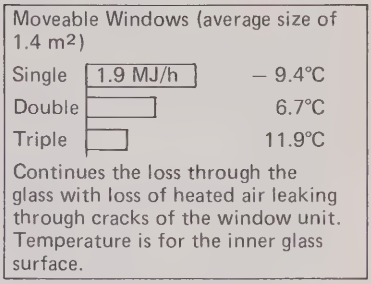
Tightly sealed fixed units have no air leakage. Loss indicated is through the glass. Temperature is for the inner glass surface.

Figure 2.10


Ceiling insulation (attic floor) based on an area of 100 m^2

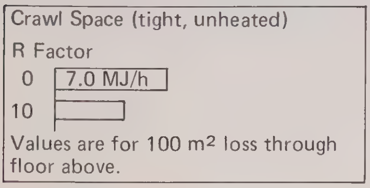
Temperature indicated is at the inner ceiling surface.

Figure 2.11


Moveable Windows (average size of 1.4 m^2)

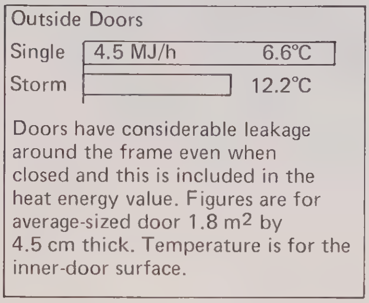
Continues the loss through the glass with loss of heated air leaking through cracks of the window unit. Temperature is for the inner glass surface.

Figure 2.12


Crawl Space (tight, unheated)

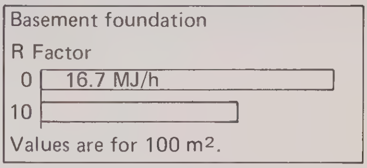
Values are for 100 m^2 loss through floor above.

Figure 2.13


Outside Doors

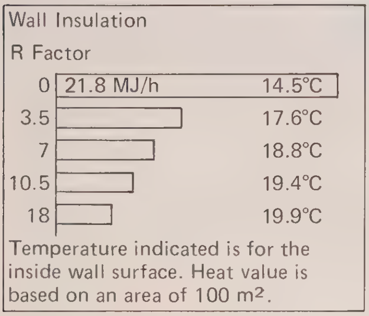
Doors have considerable leakage around the frame even when closed and this is included in the heat energy value. Figures are for average-sized door 1.8 m^2 by 4.5 cm thick. Temperature is for the inner-door surface.

Figure 2.14


Basement foundation

Values are for 100 m^2.

Figure 2.15


Wall Insulation

Temperature indicated is for the inside wall surface. Heat value is based on an area of 100 m^2.

★ Notice how the inside temperatures vary with the insulation. Why is one more likely to shiver in an uninsulated house maintained at 21°C than in a well-insulated house maintained at the same temperature?

Table 2.7

The bungalow and the two-storey house described here have approximately the same living area of 160 m^2. This would not include the stairwell in the case of the two-storey house. Both have unfinished (non-habitable) basements. Neither house has a crawl space.

	Bungalow 10 m x 16 m		Two-Storey 9 m x 9 m	
Attic Floor (ceiling)		Total 160 m^2		Total 81 m^2
Foundation walls	130 m^2		90 m^2	
Less fixed windows	4 m^2	126 m^2	2 m^2	88 m^2
Walls:				
First floor	130 m^2		90 m^2	
less fixed windows	3 m^2		5 m^2	
less moveable windows	10 m^2		4 m^2	
less outside doors	4 m^2	113 m^2	4 m^2	77 m^2
Second floor			90 m^2	
less fixed windows			5 m^2	
less moveable windows			4 m^2	81 m^2

Table 2.8

	Heat-Energy Loss Window, Wall, Etc. (MJ/m^2/h)	Bungalow Energy Loss (MJ/h)	%	Two-Storey Energy Loss (MJ/h)	%
1					
2					
3					
4					
5					
6					
7					
	Total loss (MJ/h)		100%		100%
	Total loss per m^2 of living area (MJ/m^2/h)		▨		▨

CN

3. How to Conserve Space Heat

This section looks at aspects of the fossil-fuel energy system; in particular, the home-heating oil supply. Efficiency, conversion of fuel oil to heat energy, insulation, caulking, weatherstripping, and humidity are some of the concepts dealt with. The emphasis here is on providing basic knowledge on which to act.

Conserving Space-Heat Energy – Interdisciplinary Considerations

★ One necessary use of energy in the Canadian climate is for the generation of heat to make indoor living comfortable. While the necessity for a certain amount of space-heat energy can hardly be denied, it seems obvious that the amount of heat used is far more than necessary. How can energy be saved in this aspect of living?

The conservation of space heat can be approached through various disciplines. For example, how did people keep their houses warm in the past? This single question can lead in a number of interesting directions. The tapestries of medieval times, for example, while an art form, also served as insulation for drafty castle walls; and centuries ago Eskimos discovered that snow forms an admirable barrier against the cold.

As fuel becomes scarcer, how will architecture be affected? (smaller rooms? row housing? new building materials?) How will clothing be affected? (People will wear more of it, one assumes.) This poses a large and serious value question for teen-age students. Teachers should remember their teens and be sympathetic.

The fuel shortage might also affect the pattern of living: since nights are colder than days, people might start going to bed earlier and getting up with the sun.

This particular change would have many ramifications. How would it affect the hours of school, of industry, of television, and of the entertainment world in general? Canada already has many successful summer theatres. Is this the pattern of the future, rather than heating large theatres and concert halls in the winter?

These questions can all be pursued to discover the effects of conservation on city planning, economics, food and nutrition, values, and geography (oil routes, effects of oil spills). While the prime purpose of such a study is to show how energy can be conserved, other aims may be accomplished as well. While the questions will hopefully provide teachers with starting points to introduce the energy problem into their own disciplines, it is expected that students will study space-heat energy conservation from a technical and practical point of view – that is, how to heat space more efficiently. The rest of this section is concerned with the practical aspects of conserving space heat.

Conserving Space Heat – Practical Aspects

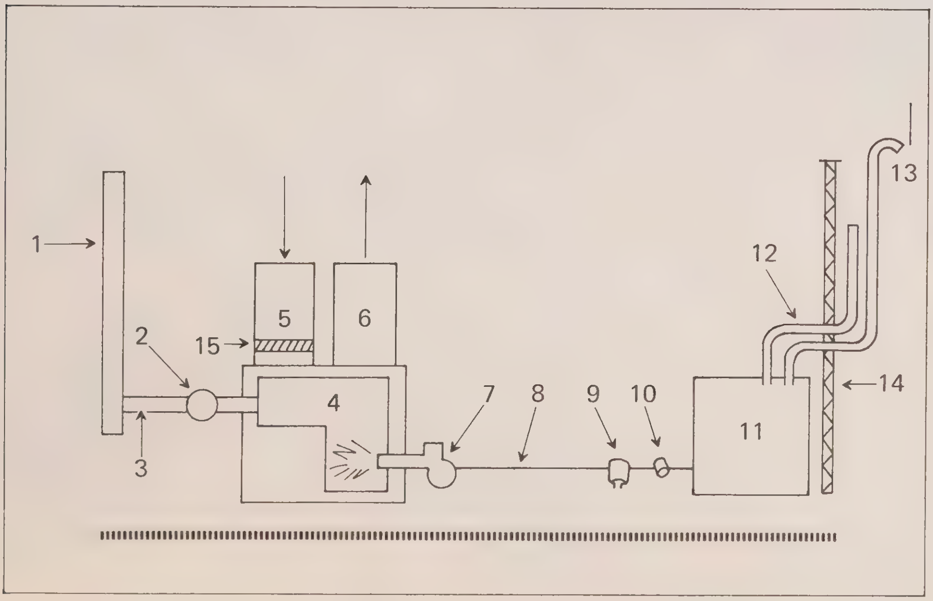
★ To maintain a comfortable temperature within a building in winter, we all use some type of heating system. There are various types: electric baseboard, electric forced air, heat pump systems and hybrid heat pumps (electrical and fossil-fired), oil-fired forced air, gas-fired forced air, gas-fired hot water, coal-fired steam. Which type is used more often in Ontario than any other? Find out by discussing the types of heating system used in your school and in your home, and by conducting a survey among your classmates and teachers to determine the kind of heating system they have in their homes.

What Are the Essential Components of an Oil-Fired Residential Heating System?

★ If possible, consult the school's building superintendent, as well as resource books, and find out the purpose of each numbered part of the heating system in figure 2.16. Then, place the appropriate number of each part beside the corresponding name. Identify these components in your home heating system. Find out the meaning of terms such as: "furnace efficiency", "heat exchange", "flue temperature", and "exhaust breeching".

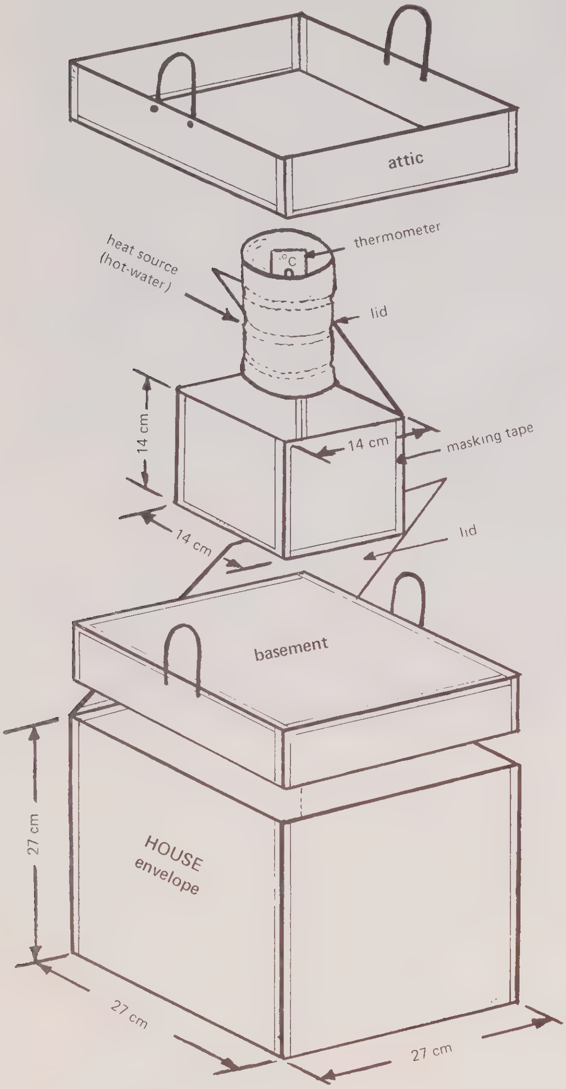
Figure 2.16

Schematic Illustration of the Components of an Oil-Fired Residential Heating System



stop valve ______
vent pipe ______
heat exchanger ______
exhaust breeching ______
filling pipe ______
fuel tank ______
output to home (warm air or hot water) ______
chimney ______
return from home ______
oil supply line ______
barometric damper ______
oil filter ______
air filters ______
wall ______
oil burner ______

Figure 2.17



★ What Can You Learn About Heating From Your School's Heating System?

If it is possible, arrange for a tour of the school's heating system. Discuss with the tour guide the fuel used, the quantity, how it is measured, how it is delivered, where it is stored, how it is prepared and handled prior to combustion, how it is burned, how the energy is transferred to the school rooms, how it is controlled, and how the heat energy produced is conserved.

★ What Is a Furnace's Maximum Heating Efficiency?

For maximum efficiency, oil-fired and natural-gas-fired furnaces should be tuned at least once a year. A furnace adjusted for efficiency can save 10 to 15% of the fuel otherwise consumed. Students should make checklists of the procedures a service person follows when a furnace is tuned. Consult a fuel-supply dealer or the school's building superintendent.

★ Learning About Energy Use in Heating by Collecting First-Order Data

Tape-record the operation of an oil-fired furnace for one hour, once on a cold winter's day and once when the weather is milder. The inside and outside temperatures should be recorded both times. Learn to distinguish between the sound of the burner and the sound of the fan. If there is a motor on the hot-water heating system, you will need to recognize its sound and ignore it.

You can: (1) play back the tapes and time the operation of the burner motor and the fan motor; (2) discover variations caused by differences in motors and in temperatures; (3) verify the firing rate of the burner nozzle (This is stamped on each burner, although the firing rate on the plate may not be the actual rate if the unit is being underfired to meet a building requirement, for instance; the actual marking on the burner nozzle is the only accurate method, i.e., 0.75 gal = 0.75 gallons per hour.); (4) find out how many litres of oil are burned during each one-hour period and calculate the joules of energy burned; (5) calculate the kilowatt hours of energy used by each motor and add this to the total amount of energy expended to determine the total energy required during each hour of use.

★ How Do Fireplaces Affect Furnace Efficiency?

The claim has been made that the use of the traditional style of fireplace increases the operation of a furnace and the use of fuel. Design an experiment to do at home to test the validity of this claim. Find out how recent fireplace designs have improved their efficiency.

★ An Important Component of the Heating System

For many people, the thermostat is the only contact they have with the operation of space heating. It is in fact a very sensitive and important component of a home's heating system. Through your own investigation and research, find out about the function and structure of the thermostat.

★ Conserving Space Heat Through Insulation

Build a "model house" insulation tester. Two corrugated cardboard boxes could be used, or the sketched model (figure 2.17) may be readily constructed and would make it easy to compare the insulative properties of various materials. Required materials include: a coffee can (454 g size with plastic top), a thermometer, corrugated cardboard, and a quantity of shredded, crumpled newspaper. Walls and floors should be cut to size and joined with masking tape. Tape will be needed on both the inside and outside corners for strength. Attic and basement trays should be cut slightly smaller for easy insertion into the house envelope.

Working with your tester will help you appreciate the relative insulative properties of various materials. In each test, the quantity of hot water used, its initial temperature, and the cooling time should be kept constant. Try one-third of a can of water at 60°C for 6 min. (Some experimentation is recommended to determine the best constants and location for your tester.)

In each test you conduct, place the hot water in the container along with the thermometer. Note the temperature of the hot water, then cover the can with its plastic cover, leaving the thermometer in the water and place the can in the house as illustrated. Note the time. For best results the tester should be immediately placed in a cool location, perhaps outdoors in winter or in a refrigerator. Immediately after the allowed time interval has passed, open the tester and note the temperature of the water. If the cooling rate (that is, the number of degrees lowered per unit per time) is twice as great for one material as for another, you may conclude that the second material tested has better insulative properties than the first one.

Some or all of the following tests could be conducted. You may wish to do others that will suggest themselves. In each case the quantity of water and the initial temperature should be constant. A hot-water tap would be a good energy source. Tests conducted outside in winter give the most definite results. Record the data in table 2.9. Study, compare, and discuss all the data collected.

Test 1. Water in can, exposed to air.
Test 2. Water in can placed in house envelope.
Test 3. Water in can with the basement, walls, and attic filled with shredded, crumpled newspaper.
Test 4. All but the attic insulated.
Test 5. All but the basement insulated.
Test 6. All but the walls insulated.
Test 7. Remove the attic and study the insulative properties of glass by covering the top with a sheet of glass.

★ Try to calibrate your insulation tester. To do so, determine the cooling rate of a number of materials with known R values such as those of 2.5 cm (1 inch) and 5 cm (2 inch) styrofoam sheets (the more the better). The R values of materials whose R values are unknown can be approximated by finding their cooling rates for the same thicknesses and comparing them with the cooling rates of the known materials.

The materials used in the construction of buildings all have some insulative value. Common building materials together with their R values are listed in table 2.10. These materials all give form and strength to the building with the exception of brick, which is used for decoration. While building materials have some insulative value, they are not referred to as insulation. Materials used specifically for insulation and their R values are given in table 2.11.

Table 2.9

Test Results

The initial water temperature, quantity of water, air temperature, and cooling time are constant.

Material	Initial Temp. (Ti) of the Water (in °C)	Final Temp. (Tf) of the Water (in °C)	Change in Temp. (Ti-Tf) of the Water (in °C)	Air Temp. (in °C)
Water in can				
Envelope only				
Envelope plus paper				
etc.				

Table 2.10

Building Materials and R Values

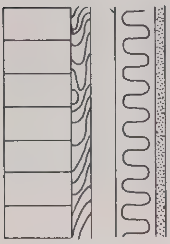
Type of Material	Thickness (in cm)	R Value
Insulating fibreboard	1	1
Insulating sheathing	1	1
Plywood	1	0.5
Gypsum board	1	0.5
Wood (various kinds)	1	0.4 – 0.6
Concrete blocks	10	0.71
	20	1.11
	30	1.28
Air space in walls	2 to 10	0.97
Glass (single-pane)		1
Glass (double-pane)		2
Glass (triple-pane)		3
Brick (10 cm size)		0.45

Table 2.11

Insulation Materials and R Values

Type of Material	Thickness (in cm)	R Value
Loose-fill		
Cellulose fibre	1	1.5
Mineral fibres	1	1.2
Vermiculite	1	0.9
Batt-type		
Fibreglass or rock wool	1	1.3
Expanded polystyrene ("Beadboard")	1	1.5
Styrofoam	1	1.3
Polyurethane	1	2.3

Figure 2.18



Determining R Values

Example: A wall consisting of brick exterior (10 cm size), 3 cm of plywood under the brick, an air space of 3.8 cm, 5.5 cm of batt-type insulation, and 1.3 cm of gypsum board.

Calculation	Thickness	R Values
Brick	10 cm	0.45
Plywood	3 cm	1.5
Air space	3.8 cm	0.97
Batt insulation	5.5 cm	7.15
Gypsum board	1.3 cm	.65
Total		10.72

Comparing Insulation Materials and Costs

The values given in tables 2.10 and 2.11 are approximations; all the insulation materials available have not been listed. Available insulation materials and their prices may be obtained from information brochures printed by manufacturers and local suppliers.

★ Prepare a table entitled "How Insulation Materials Compare" using the following headings: Insulation Material, Thickness of Material (in linear units used by the building supplier), R Value of Material (for the previously stated thickness), Cost Per Square Unit of Area (use units employed by the building supplier), Cost of One Square Unit of One Unit (R) of Insulation, Date of Price, Advantages of the Insulation Type, and Disadvantages of the Insulation type. The materials listed in table 2.11 do not include urea-formaldehyde foam, which could be added (it must be installed by an expert); urethane foamboard; and blue styrofoam.

★ Using different combinations and the thicknesses of the materials listed in table 2.12, design four walls, four ceilings, and three basement walls. Calculate the total R value of each wall, ceiling, and basement wall. The necessary data will be obtained from tables 2.10 and 2.11. Figure 2.18 is an example of the calculation you will make.

Table 2.12

Designing Insulated Walls, Ceilings, and Basements

Building Materials and Insulative Materials	Thickness (in cm)	Wall				Ceiling				Basement		
		1	2	3	4	1	2	3	4	1	2	3
Fibreboard	2.5											
Sheathing	2.5											
Plywood	2.5											
Gypsum board	2.5											
Concrete blocks	10.0											
	20.0											
	30.0											
Air space	2 to 10											
Brick	10.0											
Cellulose fibre	3.0											
	6.0											
	8.0											
	10.0											
Batts	4.0											
	8.0											
	12.0											
	16.0											
	20.0											
Styrofoam	2.5											
	5.0											
	7.5											
	10.0											

Conserving Space Heat Through Caulking and Weatherstripping

During the heating season, cold air enters and warm air leaves a building through many tiny cracks in walls and ceilings and around door and window frames, despite the fact that they're closed. This air exchange is called infiltration, and a reasonable amount is desirable: it removes odours and brings necessary fresh air to the furnace. Excessive infiltration, however, causes uncomfortable drafts and large fuel bills. Most of Ontario's residences have 0.5 or more air exchanges per hour (too high a rate), with up to 25% of the heat energy moving directly out of the house. The activities in this section provide opportunities for students to consider heat loss through infiltration and how it might be minimized.

1. Building and Using a Draft Gauge to Learn About Infiltration

★ Obtain parental approval and, wherever possible, participation before attempting this activity.

Cold drafts can cause discomfort and raise heating bills. They can be located by a simple device that you can make. Ignite one end of a piece of rope or a tightly rolled cloth; let it burn for a brief time; then put out the flame and let it smoulder. To check for drafts, hold the smoking end close to possible sources of drafts (e.g., wall cracks, window edges, and sills), as illustrated below.

Possibly, with the building superintendent's permission, you could use a draft gauge to test areas of the school. Drafts indicate the loss of too much heat. They can be prevented as follows: Caulking and weatherstripping will plug up cracks and small openings wherever two surfaces meet but do not move. Weatherstripping is usually applied where two surfaces meet and move relative to each other. In general, it is not recommended that the outside of an exterior wall be caulked unless the cracks are large enough to allow water to enter. Most caulking should be done on the inside to prevent the warm humid air from escaping. Once inside the wall, humid air should be allowed to move out freely to prevent condensation in the wall.

2. Looking for External House Cracks That Call for Caulking

★ Examine the following external areas of your home for cracks large enough to allow water to enter: (a) the joint between chimney and siding; (b) the joint between the masonry or concrete parts (e.g., steps and porches) and the main part of the house; (c) the chimney flashing; (d) the joint between windows and masonry; (e) inside corners formed by siding; (f) around door frames; (g) the joint between the window drip cap and siding; (h) the joint between the window sash and siding; (i) the joint between window sills and siding; (j) the joint between the eaves and gable moulding.

3. Checking Houses for Internal Draft Locations

★ Examine the following internal areas of your home, using a draft gauge. If there is no noticeable wind, a fan or an air pump operated by a partner on the outside would simulate breezy conditions and likely give you clearer results: (a) outside corners where two walls or a floor and a wall meet; (b) exhaust fans; (c) electrical outlets placed in exterior walls; (d) light fixtures recessed in the attic floor; (e) the sill plate or wherever else a wood frame wall meets the masonry foundation; (f) wherever a wood frame joins a masonry wall; (g) wherever a chimney joins a wall; (h) around the wood frames and edges of all doors and windows. Record the location of all drafts and indicate their strength as weak, moderate, or strong.

4. What Are the Relative Strengths and Weaknesses of Caulking Materials?

★ Compare caulking materials by preparing and completing a table like table 2.13 below. Building-supply firms will supply information concerning the application of each type of material and subsequent clean-up.

Table 2.13

Comparison of Caulking Materials

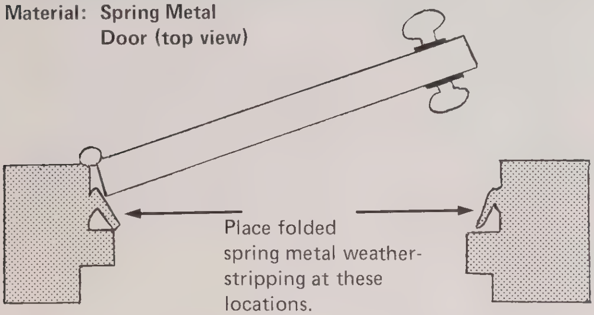
Caulking Material	Use	Trade Name(s)	How Applied	Clean-Up Solvent	Advantages	Disadvantages	Cost/gram
Oil or resin base							
Latex, butyl, or polyvinyl base							
Elastomeric caulks, silicones, polysulfides, and polyurethanes							
Filler – oakum, caulking, sponge rubber, and glass fibre							

5. Comparing Weatherstripping Materials

★ On the basis of information available from building suppliers and other sources, and after examination of weatherstripping that has been installed, prepare a booklet entitled "Weatherstripping Your Doors – Alternative Methods and Materials". Each of the following materials may be dealt with by means of a sketch and a brief description, as shown in figure 2.19: (a) closed-cell vinyl foam (sticky back); (b) vinyl-covered polyurethane foam; (c) hair felt; (d) rolled vinyl with aluminum channel backing; (e) foam rubber with wood backing; (f) spring metal; (g) interlocking metal channels; (h) fitted interlocking metal channels (J-strips); (i) sweeps; (j) door shoes; (k) interlocking threshold.

Figure 2.19

Material: Spring Metal
Door (top view)


Place folded spring metal weather-stripping at these locations.

Tools: Hammer, nails, tape measure, and tin snips.
Installation: Cut the metal to length and tack in place. Lift outer edge with a screw-driver after tacking for a better seal.
Difficulty: Easily installed.
Durability: Extremely durable.
Cost:
Comments: Almost invisible when installed.

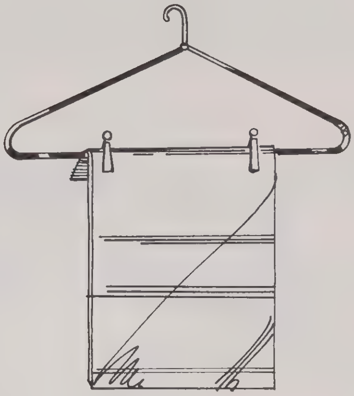
★ Windows are weatherstripped in much the same way as doors, using most of the materials described in the previous activity. Prepare a booklet entitled "Weatherstripping Your Windows – Alternative Methods and Materials" as you did for doors in the previous activity.

6. How Airtight Should You Make Your House?

★ The application of materials now on the market could reduce the infiltration rate to a point where problems arise with regard to humidity, condensation, furnace operation, and odour concentrations. This lower limit of air exchange is considered to be about 0.2 air changes per hour. How much caulking and weatherstripping should the home owner apply? One rule of thumb offered is to weatherstrip and caulk until a light fog or mist condenses occasionally on double-glazed windows on the downwind side in cold weather. Most homes require considerable sealing before they reach this degree of airtightness.

7. How Much Fresh Air Does the Furnace Require?

★ A furnace needs a considerable amount of fresh air, i.e., oxygen for combustion. You can make a draft gauge out of light paper or cellophane as illustrated on p. 27. Such a gauge will indicate the relative strength of the air current into the air intake of the burner. An adequate supply of air in the furnace room is necessary for efficiency. Students can research the quantity of air (in cubic metres) required for this purpose.



Some Activities Related to Humidity

★ On a cold day when a kettle is boiling vigorously, you can note the moisture that forms on the kitchen windows. If your house has a storm door, you can open the main door and note how moisture forms on the glass. In each case, note whether the window is single-, double-, or triple-glazed. If possible, tape a thermometer to each window and record the temperature. Note the results of breathing on each window. Does condensation take longer to appear on a single-, a double-, or a triple-glazed window?

Relative Humidity and Comfort

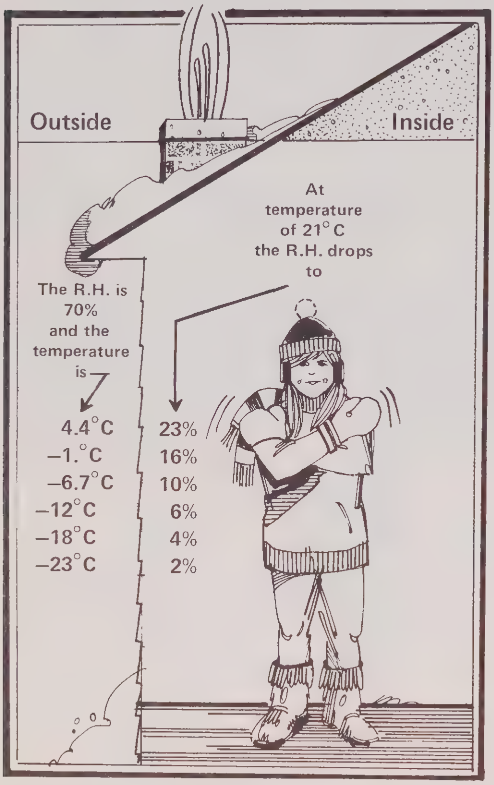
Relative humidity (R.H.) greatly influences comfort. Relative humidity can be defined as the ratio of the amount of water vapour in the air to the maximum amount of water that the air could hold at that temperature. Considered another way, if the atmosphere at 10°C is saturated with water vapour, there will be exactly 116.6 drops of water vapour each with a mass of 0.0648 g per kilogram of dry air. If the temperature of the air is raised to 20°C, it will hold 233.2 drops of water vapour each with a mass of 0.0648 g/kg of dry air. If no moisture is added in changing the temperature from 10°C to 20°C, then the actual vapour content is still 116.6 ÷ 233.2 or 50% at 20°C. It is important to note that the lower the temperature, the smaller the amount of water vapour the air will hold at saturation (see table 2.14).

Table 2.14

Temperature (in °C)	Number of 0.0648 g Drops of Water Vapour per Kilogram of Dry Air for Saturation
10	117
12.8	141
15.6	172
18.4	205
21	242
23.8	288
26.6	343
29.4	405
32.2	477

Figure 2.20 indicates what happens to the R.H. of outside air (at the temperatures indicated and with an outside R.H. of 70%) when it infiltrates a house and is heated to a room temperature of 21°C.

Figure 2.20


Outside
Inside
At temperature of 21°C the R.H. drops to
The R.H. is 70% and the temperature is
4.4°C
–1.°C
–6.7°C
–12°C
–18°C
–23°C
23%
16%
10%
6%
4%
2%

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The optimum R.H. for most people lies in the 30 to 40% range, but the percentage of humidity will vary with the outdoor temperature. At lower R.H., water evaporates rapidly from the moist surfaces of our bodies, causing a cooling effect and a chilled feeling. Most people feel the need to increase the thermostat setting several degrees in order to offset this chill.

★ List ten possible home sources of water vapour that would help to raise the relative humidity in the house.

Understanding Humidifiers and Their Effects

★ Humidifiers are usually installed in a residence in order to maintain the proper R.H. There are three general types: the evaporative plate, the vaporizer, and the atomizer. Compare the three types on the basis of litres of water vaporized per day, method of operation, advantages, and disadvantages. A chart form is recommended. You can also conduct a survey among your classmates and others to identify the most common type of humidifier. As a rule of thumb, 4.5 L of water should be vaporized per room per day in the winter. Is your humidifier adequate?

Measuring Relative Humidity in the House

★ Static electrical charges generated when people walk across carpets indicate a low relative humidity. An accurate calculation of R.H. can be made using a sling psychrometer. Record your results in table 2.15 on p. 30.

The common sling psychrometer (shown in figure 2.21) has two etched-stem thermometers fastened to a frame that has a swivel-mounted handle. A small piece of unbleached muslin is wrapped around the bulb of the wet-bulb thermometer and secured with a cotton string at the neck between bulb and stem. The wick is then wet thoroughly, but not to the point of dripping, and the unit is whirled; it should be stopped every minute or less to allow you to observe the reading of the wet-bulb thermometer. When this reading ceases to decrease, it and the dry-bulb reading are used to obtain the R.H. If the water vapour is at the point of saturation (at 100% R.H.), the two thermometers will read the same. As the R. H. decreases, the reading on the wet-bulb will become increasingly lower than that on the dry-bulb thermometer.

★ You can make a sling psychrometer. Obtain an inexpensive wall thermometer, preferably graduated in 1°C divisions. The model shown (figure 2.22) uses a forty-cent plastic-backed thermometer; the plastic is cut as illustrated so that the bulb projects freely into the air. Fasten the thermometer firmly to a scrap of wood, using masking tape over the lower and higher portions of the scale. (Finishing nails were added to this model for greater security.) A small fringed skirt was fashioned to tie on the bulb. To use: Holding the psychrometer as shown, whirl it rapidly (and carefully) until the lowest dry-bulb temperature is attained. The skirt is then tied around the bulb. When wet, the psychrometer is whirled rapidly until the lowest wet-bulb temperature is attained. To convert the two readings to R.H., make a slide rule as shown in figure 2.23. Set the scales so that the wet-bulb reading lines up with the dry-bulb reading. The arrow will point to the R.H.

The sling psychrometer in figure 2.21 is reliable to 2% when properly used. The one described here is reliable to 5%.

Figure 2.21

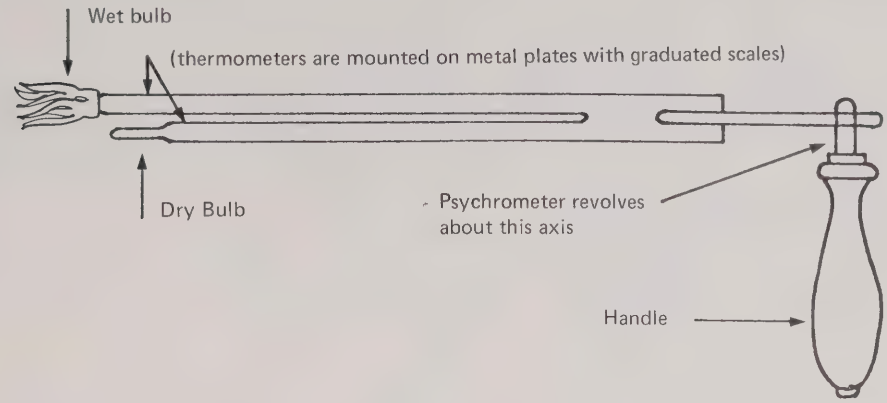

Wet bulb
(thermometers are mounted on metal plates with graduated scales)
Dry Bulb
Psychrometer revolves about this axis
Handle

Figure 2.22

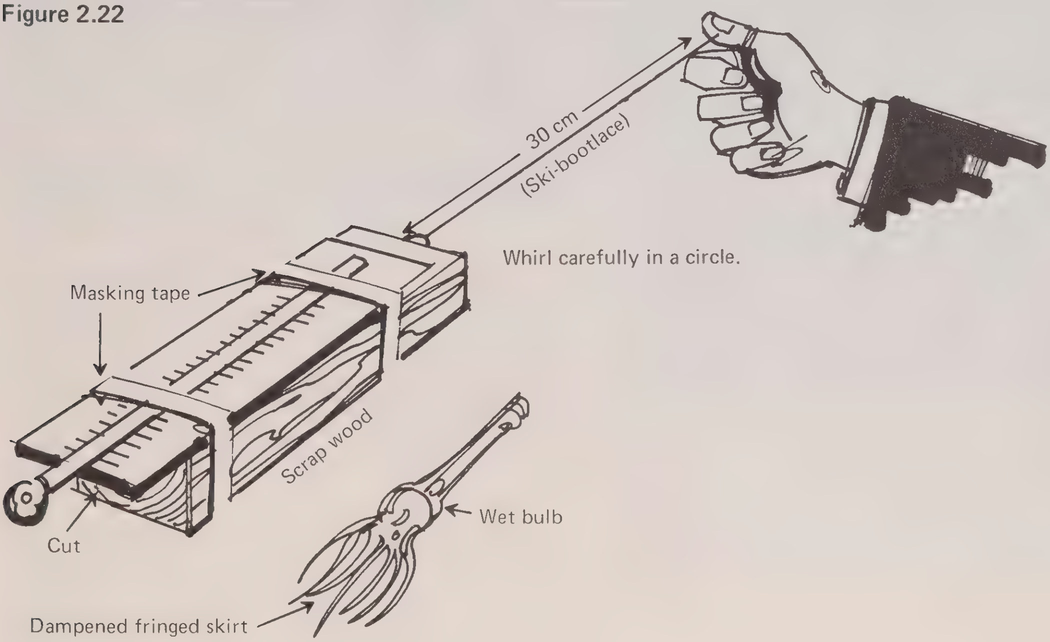
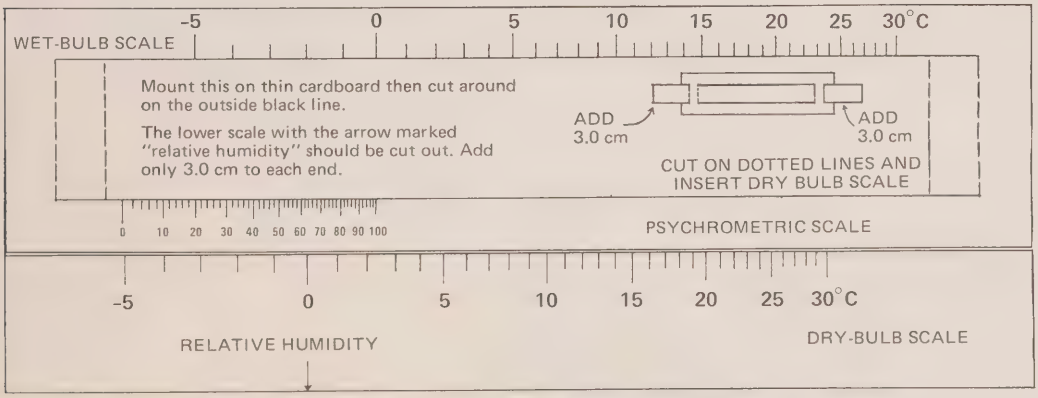


Figure 2.23



Mount this on thin cardboard then cut around on the outside black line.

The lower scale with the arrow marked "relative humidity" should be cut out. Add only 3.0 cm to each end.

CUT ON DOTTED LINES AND INSERT DRY BULB SCALE

Source: Adapted from *Popular Mechanics Do-It-Yourself Encyclopedia,* vol. 8 (New York: The Hearst Corporation, 1968).

Table 2.15

Comparing Levels of Relative Humidity

Location	Dry-bulb Temp. (in °C)	Wet-bulb Temp. (in °C)	R.H. (%)
Bathroom just after a hot shower			
Living room			
Kitchen			
Classroom			
Hall			
Outside			
Compare your results with others. Repeat on different days.			

Checking the Tightness of Your Home

★You may obtain an indication of the tightness of your home by using the sling psychrometer. On a cold afternoon when you are not boiling water, or running baths or showers, etc., use your sling psychrometer to determine the R.H. in your living room, hall, and bedroom. Turn off your humidifier. After a half hour, determine the R.H. If it has dropped significantly, your house may be loose. You should repeat this experiment on different days before making any firm decision.

4. Conserving Space-Heat Energy – An Action Plan

The purpose of this section is to suggest an action plan for students who have made a commitment to conserve. The plan can be undertaken by an individual or through group action (by a school energy-conservation team, for example).

If a community were to adopt the following conservation measures, large savings in space-heating energy would be made. Items in the list have been coded according to difficulty. Individuals or a school energy-conservation team could use the following checklist as a guide for action or to determine the efficiency of their own or, on request, their neighbours' current space-heating practices.

• These are conservation measures that require no technical skill and can be practised immediately.

•• These are conservation measures that require very little technical skill but will require a small investment of money.

••• These are conservation measures that require some technical skills, skills that a student could readily acquire. Some investment of money in materials and equipment would be required; however, the investment would be modest and the potential return of the money spent by a home owner well worth while.

•••• These measures should only be carried out by a competent service person.

By completing an in-depth study of the following measures you will develop an expertise sufficient to allow you to advise on most space-heating conservation measures necessary within a school community or to apply them yourself.

1. Thermostat Control

• Residents should set the thermostat at the lowest comfortable temperature during the daytime. This might be 20°C or even lower.

• Do the residents lower the thermostat at night? (While it is true that the lower the setting the greater the saving, it is not recommended that the setting be too low, as on extremely cold nights the recovery period in the morning may take too long.)

Note: Savings that come from setting back the thermostat vary, depending on how well a residence is insulated. As a guide, you can expect to save 4 to 6% of the fuel used for each 1°C the thermostat is set back. If the house is very well insulated, then the saving could be less than 4%. Later checks in this action plan will show you whether the house is well-insulated or not.

• Are there any heat-producing appliances near the thermostat to influence its reading? If so, they should be removed.

• Is the thermostat on an inside wall, free from window and door drafts?

•••• If the heat source and/or the window and door drafts cannot be removed, then the thermostat should be moved to a better location.

• Do the residents lower the thermostat when they are away? (It is not recommended that the setting be lower than 10°C.)

• Do the residents wear warm clothing, which covers the arms and legs and permits them to be comfortable or warm without loss of ease of movement?

2. Reducing Infiltration

• Is the *fireplace damper* kept closed whenever the fireplace is not being used?

••• Is there a *fireplace shield* (insulated fireplace plug) which is in place when the fireplace is not in use?

• Are residents careful to turn off any *exhaust fan* once unwanted household odours have been removed?

• Do residents attempt to minimize the opening of *doors and windows?*

•• Conduct a draft-gauge check and an outside visual check and note any necessary corrective steps (caulking and weatherstripping).

•• Check the *sill plate* with a draft-gauge and seal it if necessary.

•••• If there is a *vestibule* without an inner door, an inner door would provide a good form of insulation.

3. Relative Humidity

•• Check to see that there is the proper degree of humidity in the house. If the humidity is not adequate (30 to 40%), check the humidifier to see if the evaporative plates or belts need replacing. Note whether the present humidifier size is adequate or not.

Table 2.16

Insulation Check

Structure	Area m^2	Estimate of Present R Value	Estimate of Heat Loss	Recommendation for R Value (MJ/h)	Estimate of Heat Loss After Insulating (MJ/h)
Ceiling					
Basement					
Crawl space					
Walls (net)					

Window Check

Type:	si	do	tr	st	pl		Recommendation	
	(area in m^2 for each)							
Movable								
Fixed								
Door check	single or storm (area in m^2)							
si = single-glazed; do = double-glazed; tr = triple-glazed; st = storm; pl = plastic						Total MJ/h		Total MJ/h

4. Insulation, Storm Doors, and Storm Windows

- Table 2.16 will help you determine the need for additional storm doors, storm windows, and insulation. Using the graphs on p. 17, estimate the heat loss per hour in megajoules from the various structures listed.

Recommend an R value for storm windows or doors and indicate the projected saving in heat energy per hour after the conservation measure has been carried out. *Remember that the heat loss represented in the graphs is for a frame-constructed house when the temperatures are as described on p. 17.*

5. The Heat Production-Distribution System

•••• Is the furnace cleaned and the burner adjusted for efficiency at least once a year by a competent service person?

- Is the air shutter on the burner checked regularly to see that it is free from any obstruction?

- Are the air registers free of obstructions?

- Are the air filters changed or cleaned monthly during the heating season?

- Check the colour of the smoke leaving the chimney on oil-fired furnaces. If the smoke on a cold day is white, then the furnace could be operating properly; however, if it is grey or black, then the burner likely needs to be tuned.

- Check the colour of the tip of the flame of an oil-fired furnace. Open the inspection door (be careful: it is probably very hot) and observe the tip of the flame. If it is black and the flame is a dull yellow, your burner needs to be adjusted.

Do not make your judgement too soon; the moment the door is opened the flame colour will change due to the admission of additional oxygen. The proper flame should have no smoke associated with it. Lack of smoke is not the *only* indication of a proper flame; air pressure, nozzle pattern, and several other factors are involved. If you are unsure or hesitant about completing this activity, ask your teacher or another adult to help you.

••• Monitor the flue-gas temperature and the circulating temperature throughout the heating season on a weekly basis.

★ Other Learning Activities Related to Space Heating

1. Using a tape recorder, interview other students, neighbours, and others in your community to determine their attitudes towards space-heating energy-conservation practices. The following questions might be asked:

a) Do you feel it is necessary for Ontario residents to conserve the energy used to heat their homes?

b) If you feel that we should conserve heat energy, what have you done in your house towards this goal?

A group of students could work out suitable questions that would bring out community attitudes on this matter. An examination of the taped interviews could provide information that would be useful in preparing a statement to sum up the general community position.

2. Research the methods by which refineries convert crude oil to heating oil.

3. Obtain information on wood furnaces. Are they as efficient as oil-fired furnaces? What are the problems associated with their operation?

4. Research various methods of community heating such as one central heat source. What are the advantages and disadvantages of such a system?

5. Interview your grandparents (or some older members of the community) to find out how they heated their homes when they were children. Do they feel that today's methods of home heating make the quality of life better?

6. Set up a simulation situation or role-play the following situation: Imagine that a fuel-oil–natural-gas rationing board has been established in Ontario. For the new heating season, you will receive only three-quarters of the fuel that you used last heating season. What change in your present life style would be required in order to adjust to the rationing?

7. Design ten posters that will inform people of the need to conserve space heat.

8. Discuss the following situation: If the fuel-oil sources presently used in Ontario were to be exhausted in forty years, what jobs in your community would likely disappear?

9. Conduct a study in which you identify various ways of heating space used by different peoples around the world. Why do each of these ways suit each nation or group of people?

5. Bibliography

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Part 3, Electrical Energy

Table of Contents

Introduction 2

1. Getting Started 3

2. Electrical Power – Energy and Accounting 17

3. Converting Electrical Energy in the Home 23

4. Saving Energy Saves Money 36

5. Problems With Meeting the Demand 41

6. Action Plans 49

7. Support Materials 50

8. Bibliography 54

★ A star beside the text indicates an investigative activity for students.

Introduction

Until recently, dams in Ontario watersheds provided more than an adequate supply of water for the generation of hydro-electricity. As our population grew along with our demands, this hydro-power had to be supplemented with thermal electricity, which requires fossil fuels, and, very recently, nuclear energy as the primary sources of energy.

Our technology has yet to provide ways of storing large amounts of electrical energy. As a result, electricity must be generated *on demand!* We cannot stockpile it. The problem is further complicated by the fact that our demands change with time. Peak periods occur – during the day, week, month, and year – when the present generation and transmission facilities are pushed to their limit. At other times, they can meet the demand without strain. The "base" or minimum demand is also on the increase, however, due to our energy life style.

Electricity began as an industrial necessity in highly concentrated industrial areas such as Kitchener, Guelph, and Toronto. What was once considered a necessity for industry has grown into an accepted way of life in our homes and businesses. We now have a high standard of electrical living.

As the price of fossil fuels increases, so does the price of electricity. Approximately 42% of the electricity generated in Ontario in 1976 was derived from fossil fuels not indigenous to our province.

Our technology is constantly finding ways to prevent the environmental pollution caused by burning fossil fuels to generate electricity. Such research and development adds to the cost of electricity. Consequently, conservation and a reduction in the use of electricity will help to hold down costs and to preclude the building of more generating facilities.

The activities in the following sections are designed to give you a feeling for how we employ electricity in our homes and how we can decrease its role in our life style through conservation. Considerable encouragement is given to an examination of the values we hold towards energy use. It is perhaps the modification of these values that is the principal requirement for the adoption of wise conservation efforts in the home and in the wider community of which the home is a part.

Overview

This unit is divided into seven sections in order to group activities into related areas. Most activities either give students things to do (to collect data or conserve energy) or to discuss in order to clarify and perhaps modify their opinions.

The majority of activities in the first section ("Getting Started") are centred around the electric meter which is present in almost every home. Other introductory concepts and an energy-conservation game are included.

In the second section ("Electrical Power – Energy and Auditing"), a careful distinction is made between *power* and *energy*. Activities related to both for any electrical device or collection of devices are presented.

Section 3 ("Converting Electrical Energy in the Home") is the major section of the unit. Many activities dealing with the variety of electric appliances and devices in the home are considered.

The activities in the fourth section ("Saving Energy Saves Money") use information from electrical bills with regard to the cost of electrical energy. This aspect is incorporated into earlier activities.

Section 5 ("Problems With Meeting the Demand") expands the system from the home into the community and other sectors of society. Problems related to generation and transmission are referred to.

Section 6 ("Action Plans") gives suggestions for student activities that can be completed on the conclusion of the study of the electricity unit.

The last section contains data tables, a glossary, and a selected bibliography.

It will be observed that activities in this part link up with ideas developed in the previous part on space heating. The study of these two energy systems, and the others that are to follow, attempt to show that there is but one single, comprehensive, and unified energy-delivery system operating on the planet.

Using the Document

The target grade levels for this document are those in the Intermediate and Senior divisions. A variation will thus be observed in the difficulty of the assignments. Teachers should carefully select those most appropriate to the age level they are teaching.

It is hoped that by photo-reproduction methods many of the activities can be used without any alteration. They are unnumbered so that the teacher can make an appropriate selection; it is not intended that each student do every activity.

Although many of the activities will fit nicely into existing science courses, it is intended that they be used in any area involving the discussion of energy in society. The depth of treatment will depend only on the time made available in the curriculum for the inclusion of this information on electrical energy and its utilization.

A Note of Caution

Electricity can be dangerous if normal common sense is not employed. Like fire, electricity is not to be played with, since injury can result from unwise actions. The activities in this unit have been designed with safety in mind: they *will not* bring the student into any dangerous situations. However, teachers are encouraged to remind students of the normal precautionary steps to be taken when using electrical appliances if these are involved in any way in the activity under consideration.

1. Getting Started

This section starts with some activities to get students thinking about the various ways in which we use electrical energy and whether or not it is really necessary to conserve it. Since Ontario Hydro is virtually the exclusive producer of this form of energy in the province, activities relating to Hydro's structure and operation are suggested.

Immediate monitoring of the home's use of energy, on a daily basis, is developed through activities designed around reading the electric meter. The house is treated as a single component of the residential sector of our society. Thus, students can begin to appreciate the amount of energy used in their homes in relation to the homes of others in the community.

The game "Kazam", similar to "Snakes and Ladders", is suggested at this stage in order to help students appreciate the relative amounts of energy used by different appliances as well as good and bad decisions concerning their use.

Starting Points

The following are some ideas to start your classes thinking about electrical energy. Choose from these ideas or create one that suits you and/or the class situation. The activities throughout this section have been written for students and can be given to them as presented.

★ Start a file of newspaper clippings dealing with energy conservation in general and electrical energy conservation in particular. When several have been collected, hold a discussion about energy conservation. Include in the discussion relevant radio and television announcements.

★ Look around the classroom and list:

1. any device using electricity *at the time*

2. any device that *would use* electricity directly

3. manufactured items that have *not* involved electricity in their production (virtually none in this day and age!)

★ Hold a debate and take a class vote on whether or not we *should* attempt to conserve energy. (Is it *really* necessary?) After this unit has been concluded, take the vote again.

Each day we use many electrical devices or appliances, directly or indirectly, to do things for us. The decision we make to use these things causes electrical energy to be converted to other forms of energy.

★ List your uses of electricity in order from necessary to unnecessary. Describe what life would be like without the various uses of electricity. Develop a scale from a level at which you are unable to survive to a level of ultimate luxury. Discuss whether happiness can be equated with the use of energy. Consider luxuries – what would you be willing to give up right now?

★ List the various forms of energy you use that have been converted from electrical energy. In each case, name the device or appliance that does the job. In many cases there will be more than one type of energy produced in the conversion; if this is true, list them after the name of the device as "by-products" or "waste" energies.

Now, just who provides you with this "clean" and "silent" form of energy? As you can see by these first few activities, the use of electricity has extensive ramifications.

Ontario Hydro

Ontario Hydro, either directly or through 352 co-operating municipal utilities, meets more than 90% of the province's requirements for electricity. The remainder is provided by private utilities and companies generating power mainly for their own requirements. In general, Ontario Hydro is responsible for the generation and transmission of electric power and its sale to the municipal utilities. At the same time, it acts as a central supervisory body with power to approve and control certain features of the utilities' operations. In most cities and towns and in many villages and heavily populated township areas, the retail distribution of power is the responsibility of the municipal electrical utilities which own and operate the distribution systems. In the remaining cases, the retail distribution is done through Ontario Hydro directly.

★ As your group or class works through this unit, have one or more members collect information on Ontario Hydro, using the following questions to get started:

1. How is Ontario Hydro organized and from whom does it receive its authority?

2. How has Ontario Hydro developed from its beginnings, and what are its proposals for the future?

3. To what extent are primary sources *other than* fossil fuels and uranium being explored? What is Ontario Hydro's stand on the use of solar energy, fuel cells, wind, etc., to assist in electrical-energy generation?

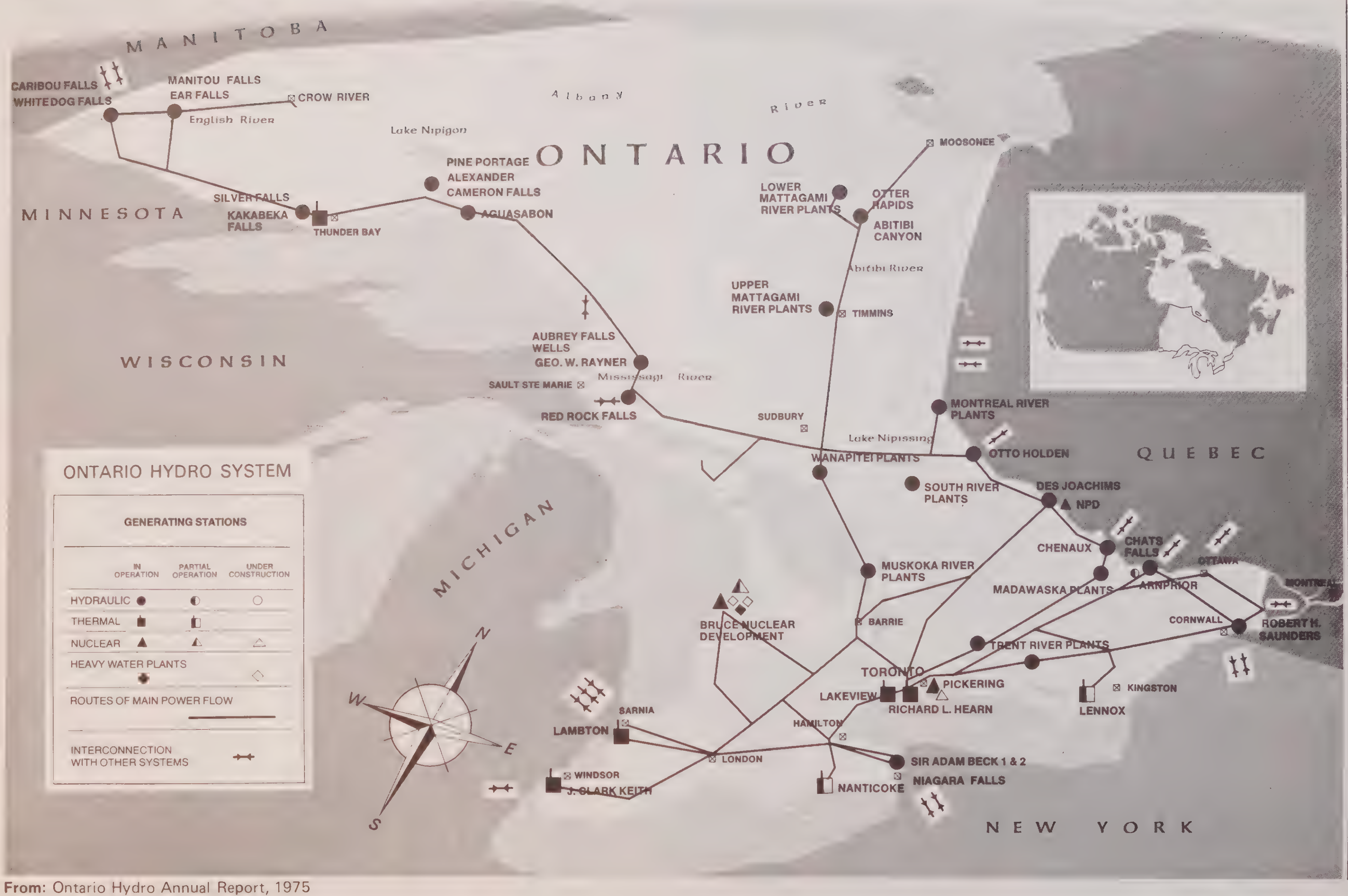
4. Determine whether your energy comes directly from Ontario Hydro or through a municipal utility. (Look at an electrical bill for your home!)

★ 1. Using the map on the next page (figure 3.1) of Ontario Hydro stations and power flow, determine: (a) the generating plant nearest to you (Can you visit it? Does Ontario Hydro allow or promote visits?); and (b) the location of the nearest distribution station.

2. What is meant by the term "electrical grid", and how are the indicated "power connections" related to this concept?

3. Under what conditions would Ontario Hydro export (import) electrical energy?

Figure 3.1
Ontario Hydro System

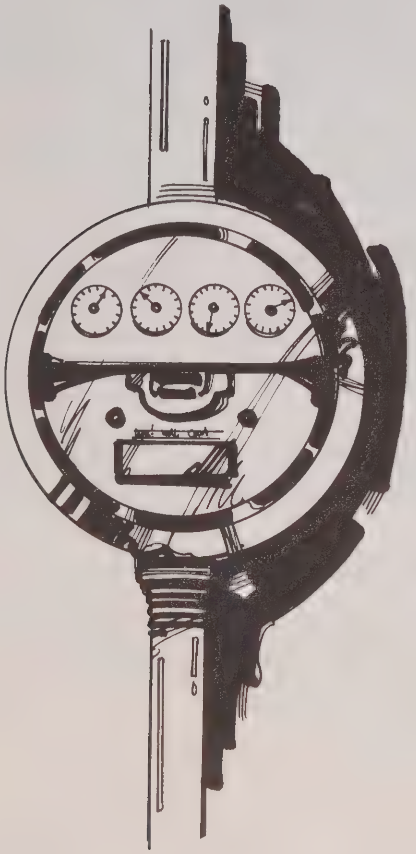


From: Ontario Hydro Annual Report, 1975

The Electric Meter

The power that is developed and distributed by your utility enters your house where it is used to perform a multitude of tasks.

Energy costs money, and in order to monitor your use, the utility provides a meter when the service is installed. This meter is read regularly and is the basis for determining your electric bills. The meter will be used here in a variety of activities to assist you in understanding how you use (or misuse) electric energy.



Source: Ontario Hydro, "Electricity at Home"

★ Locate the electric meter in your home. It is usually found on the wall outside the house or on the basement wall near the main fuse and switch panel. In an apartment, the meter is probably in the basement. If it can't be located, the building superintendent can help.

★ Determine the location of the school's electric meter and arrange for a specific student to be the "reader".

Your electric meter has an important job to do. It measures how much electrical energy is consumed by the lights and electrical appliances in the home. Learn how to read your meter so that you can keep track of how much electrical energy you and your family use each day. By keeping records, you will be able to monitor the effectiveness of any energy-conservation program you institute.

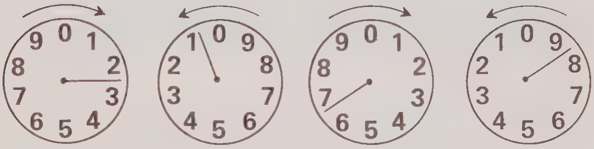
Some meters will give a direct reading on an odometer-type display and others will have dials like the examples shown in the figures. The dials are normally organized from left to right. When the pointer is between two numbers, *read the lower number*. Be careful, some dials turn counter-clockwise.

Your meter may have four or five dials. The kilowatt-hour reading can be obtained by reading the dials and by using the multiplier (if applicable) shown on the face of the meter.

Your electric meter, like the odometer in a car, gives a total cumulative reading – in this case the total amount of electrical energy consumed up to a point in time measured in kilowatt hours (kW•h). The tables in section 7 give conversions to megajoules (MJ).

Figure 3.2

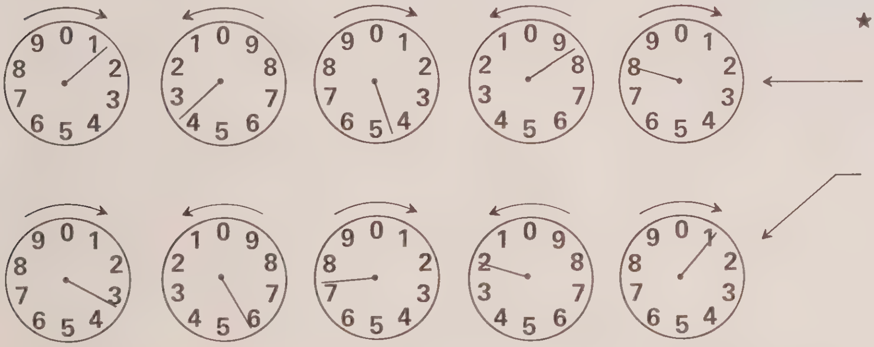
(Multiply by 10)



Read 20 680. (20 685 is also correct.)

Do you think the number of kilowatt hours in figure 3.3 represents the amount of electrical energy converted in a day, a month, a year, or longer in an "average" home? Convert this amount to the equivalent number of megajoules (MJ) of energy.

Figure 3.3



★ **Try this!**

1st reading = ________ kW•h

2nd reading = ________ kW•h

difference = ________ kW•h

The arrow indicates whether the dial is turning clockwise or counter-clockwise.

Table 3.1

Date	Time	Meter Reading	Energy Used Since Previous Reading (kW·h)	Number of Days Since Previous (d)	Average Energy Used Per Day In Kilowatt Hours (kW·h/d)	Change in Daily Consumption (+ or –)
1977 03 11	13:30	86230				
1977 03 13	13:45	86859	629	2	314.5	

★ Produce a model of the dials on the meter out of cardboard and have a pointer on each capable of turning. Use this to teach others how to read the meter.

★ Before going to school one day, read your meter and record your reading. Then (something you shouldn't usually do!) leave on electricity-consuming things that are usually turned off, such as extra lights, the TV, the radio, and so on. Let this continue to the evening (not overnight!). Next morning, read the meter and record the reading. That day, conserve electricity by turning on *only* those items that are necessary. On the morning of the third day, read the meter again. Compare the number of kilowatt hours used the first day (reading #2 – reading #1) to that of the second day (reading #3 – reading #2).

What was the difference in kilowatt hours used between the two days? Calculate what percentage the saving was of the total used the first day.

★ If you are doing the next activities in school, speak to the custodian and set up procedures in order to obtain the daily meter reading. Invite the custodian to give the class an overall view of the use of electrical energy in the school. (Involve the custodian in the project.) Where does he or she think electrical energy could be conserved in the school? Are steps already being taken to conserve?

★ Design a chart (similar to table 3.1) to record your meter readings. It should include enough lines to make an entry each day for a month.

The best time to read the meter each day is when it is both convenient for you and *when little power is normally being used.*

★ Read your meter each day for one week. Calculate the average kilowatt hours used per day and the kilowatt hours per person used each day. Compare the last figure with others in your class or group and develop a class or group average.

★ Convert the average number of kilowatt hours per day per person to joules per day and to the number of "energy slaves" by referring to the tables at the end of section 7.

★ Read your electric meter at the *same time* each day for one week. By subtraction, find the number of kilowatt hours used each day and plot a bar graph. Explain the changes in daily consumption. By extending this idea to once a week, you can audit the electrical energy you use. You can see the direct and immediate results of decisions made. In this way you can monitor the results of any conservation plan you come up with to insure that it results in the saving you predict.

If you live in an apartment building that does *not* have individual meters, it is likely that the rent includes the cost of the electrical energy used. If more than one apartment is involved, how is the total cost shared? How does this affect your conservation efforts?

★ Survey the tenants in such a building regarding their attitudes towards conserving electrical energy. How does their concern relate to the fact that they do not pay *directly* for the energy they use?

Future Demands for Electrical Power

The total generating capacity, projected into the future, will depend to a large extent on the demands for electrical energy made by Canadians. Historically, it has been increasing at about 7% per year (6.6% between 1950 and 1975) (see table 3.2).

Table 3.2

Canada Total: Projection of Installed Electrical Capacity — High Growth Case (Megawatts)

	Hydro	Nuclear	Other**	Total
1975*	36 800	2 660	20 080	59 540
1980	46 700	6 900	25 400	79 100
1985	61 900	17 800	31 400	111 100
1990	72 500	29 500	49 800	151 800

Note: The high-growth case reflects the expansion plans of provincial utilities as of end—1975. The recent announcements of delays in capacity-expansion programs are not reflected.

* Estimate

** Includes electrical power generated from coal, oil, and natural gas

Source: Department of Energy, Mines and Resources, *An Energy Strategy for Canada: Policies for Self-Reliance* (Ottawa: Publishing Centre, Supply and Services Canada, 1976, p. 86.

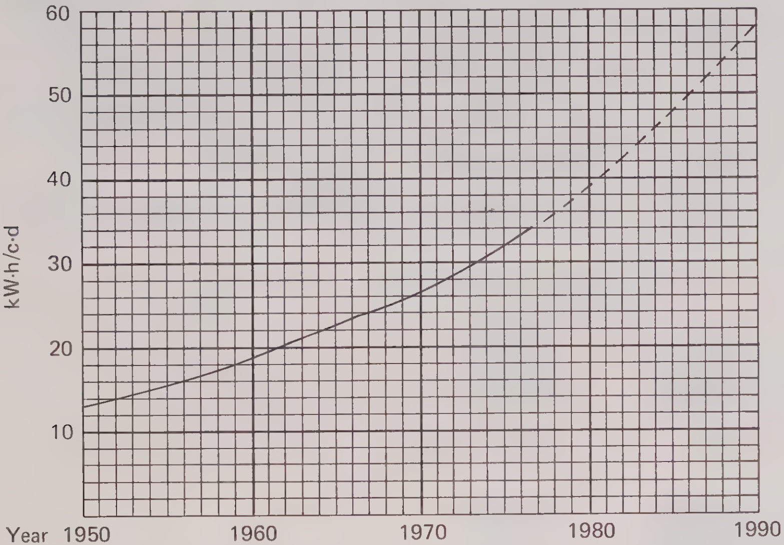
The high-growth case suggests that total generation of electrical power would increase from almost 60 000 MW in 1975 to about 152 000 MW by 1990. Such expansion would be designed to meet Canadian demands for electricity that continue to increase at an average growth rate of about 7% per year, and corresponds to utilities' expansion plans as determined by a survey of electrical utilities conducted by Energy, Mines and Resources in late 1975. The additions would most likely consist of nearly 40% in hydro-electric capacity or about 35 000 MW, principally in British Columbia (11 000 MW), Manitoba (4 500 MW), and Quebec (17 000 MW). Conventional thermal generation using coal or oil would add 29 000 MW or 31% of the total, including British Columbia (4 000 MW), Alberta (5 000 MW), and Ontario (12 000 MW) as well as substantial additions in Saskatchewan, Quebec, and the Maritime provinces. The third segment is nuclear capacity located in Ontario (19 300 MW), Quebec (5 100 MW), and the Maritimes (2 400 MW) for a total of nearly 27 000 MW or 29%

Source: Department of Energy, Mines and Resources, *An Energy Strategy for Canada: Policies for Self-Reliance*, p. 68.

★ Use table 3.2 to plot a graph of our projected demands in gigawatts from 1975 to 1990. Use different colours to show "Hydro", "Nuclear", "Other", and "Total".

Figure 3.4

Average Electrical Energy Use Per Person Per Day in Canada



Adapted from Douglas Paul, Denny Pierce and Kenneth Stief, *Energy and the Conservation Laws* (Toronto: Holt, Rinehart and Winston, 1970), p.72.

★ Use the information in the quotation on p. 6 to construct a bar graph to show where the expected increases in electrical capacity are to come from. Shade in Ontario's contribution and draw conclusions.

★ For a variety of reasons, which are referred to in later sections of this unit, a growth of 7% cannot realistically continue. At this time, list what you think these reasons are. You will be asked to refine this list later.

Table 3.3

Canada Total: Projection of Installed Electrical Capacity — Low Growth Case (Megawatts)

	Hydro	Nuclear	Other**	Total
1975*	36 800	2 660	20 080	59 540
1980	42 500	6 200	23 700	72 400
1985	55 500	12 800	29 500	97 800
1990	66 200	22 200	36 800	125 200

Note: The low-growth case has been generated within Energy, Mines and Resources and represents a capacity expansion program to meet load growths that increase on average by 5.5% per year from 1976-90.

*Estimate
**Includes electrical power generated from coal, oil and natural gas

Source: Department of Energy, Mines and Resources, *An Energy Strategy for Canada: Policies for Self-Reliance* (Ottawa: Publishing Centre, Supply and Services Canada, 1976), p. 68.

★ Use the data in table 3.3 to draw a graph similar to the one you drew for the high-growth case. What affect would this growth rate have on Ontario Hydro's planning? Refer to the conclusions you made in the activity above.

Each person's energy demands do not remain constant. We try to increase our standard of living, which means we use more energy. Figure 3.4 shows the changing average electrical energy demand per person in Canada for the period from 1950 to 1990.

> If the predictions displayed in this graph are correct, during the period 1950 to 1990, an individual's demand for electrical energy will increase by a factor of 4. This, coupled with a predicted doubling of the population (actually 2.2) during the same period, would produce an increase in energy demand of 2.2x4 = 9 times during a 40-year period.

Douglas Paul, Denny Pierce, and Kenneth Stief, *Energy and the Conservation Laws* (Toronto: Holt, Rinehart and Winston, 1970), p. 72.

★ Compare the value given in figure 3.4 for electrical production per person this year to the amount of electrical energy per capita your family uses per year. What reasons can you provide to explain the difference?

★ Use the graph and the population estimates given for Canada in the tables in section 7 to determine the total predicted energy demand by Canadians (in kilowatt hours or gigajoules) for the years 1950 to 1990.

★ Use the energy-slave calculations in section 7 to convert the number of kilowatt hours per person per day to the equivalent number of electrical energy slaves. Do this for 1970, 1975, and 1980.

★ Draw conclusions based on the knowledge gained from completing the above activities.

"Kazam": An Electrical Energy—Conservation Game

"Kazam" is an energy-conservation game for the entire class or for the family – from age five to adult. It is easy to play, lots of fun, and, most important, helps in learning some basics of electrical energy conservation.

The game package includes:

1. rules of the game
2. draw cards
3. markers
4. complete playing surface

All you need to provide is a die. (If you don't have one, use a sugar cube with inked-in dots.) To make the game board sturdy and long-lasting, paste it to a piece of cardboard. Do the same with the markers and the draw cards.

Rules

1. Each draw card is either a good or a bad conservation idea. Most cards indicate which is which, but a few don't. The players, as a group, must decide and mark this on the back of the cards. They must also decide for every card how good or how bad the idea is by rating it on a scale of one to ten. For example, if you, as a group, think an idea is a minor one, mark it "Advance 2" or "Go back 2". If you think the idea is a major one, mark it "Advance 10" or "Go back 10". Try to use all the numbers. As you proceed through the unit, you will learn the relative values of different ideas and you may change the numbers you put on the back of the draw cards.

2. Shuffle all the draw cards and place them face up on the table.

3. Each person chooses a marker. Place it to the left of number one – just off the board.

4. Each person shakes the die (use one die only) – highest number begins.

5. If you land on a draw-card space, pick up the top card from the pile and move according to the value the group has decided on. For example, if you land on 3, draw a card, and if it is marked "Advance 4", move to 7. If it is marked "Go back 4", go back to the beginning. You have to roll a 6 to get back in the game.

6. Place the card you picked at the bottom of the pile, face down. When all the cards are drawn, reshuffle and place them face up again.

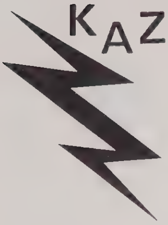
7. If you land on a picture, follow the arrow on the electrical cord in the correct direction – either backward or forward.

8. The first player to reach 100 (a smiling face) wins the game. *You must throw the exact number to win,* e.g., a player on 99 must roll a 1, etc.

9. When there is a winner, the other players can play for second or third position if they wish.

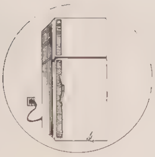
10. Two or more players can land on the same number at the same time.

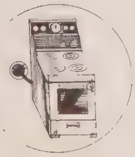
KAZAM



Plug into this game!

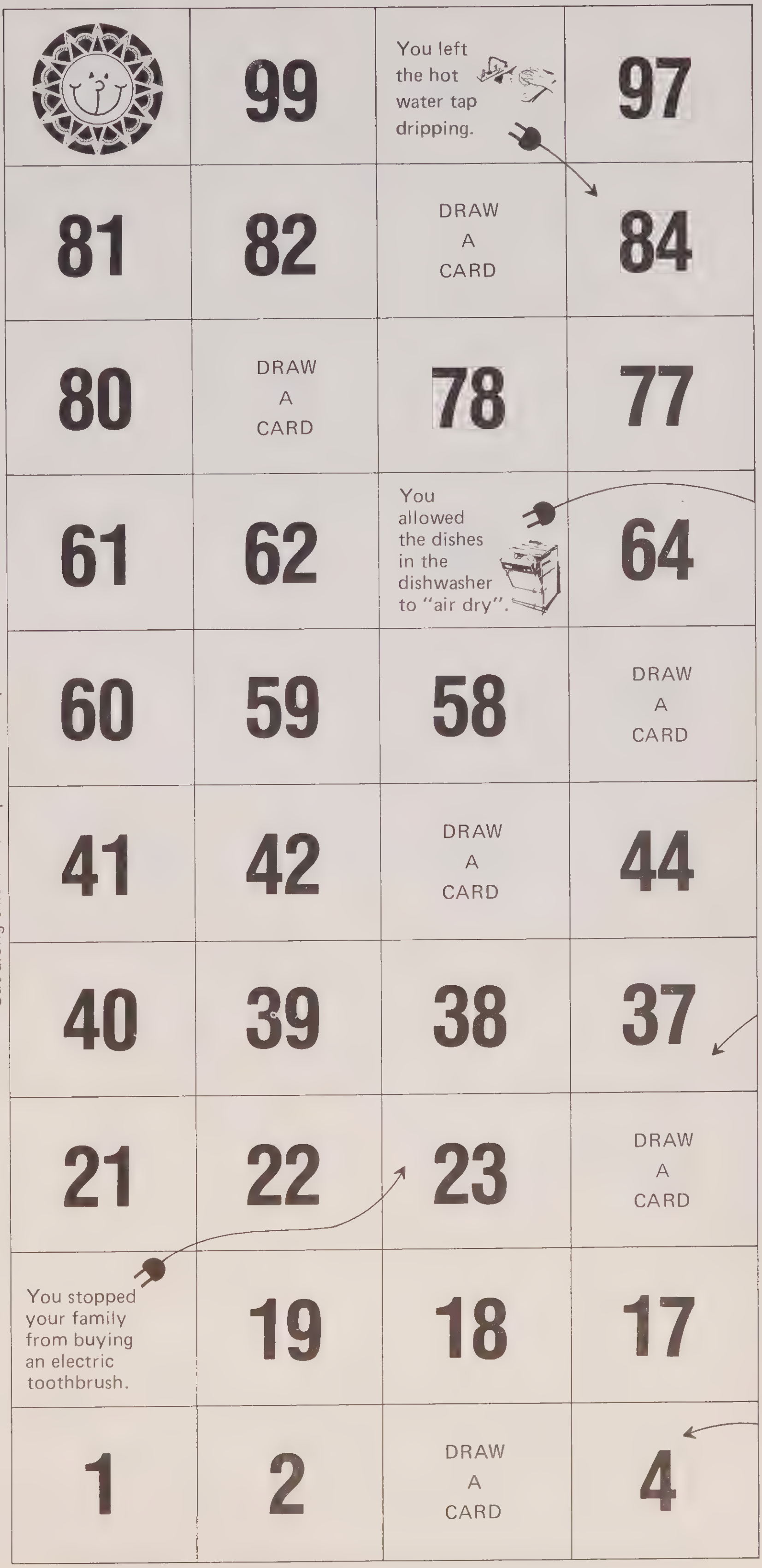
MARKERS



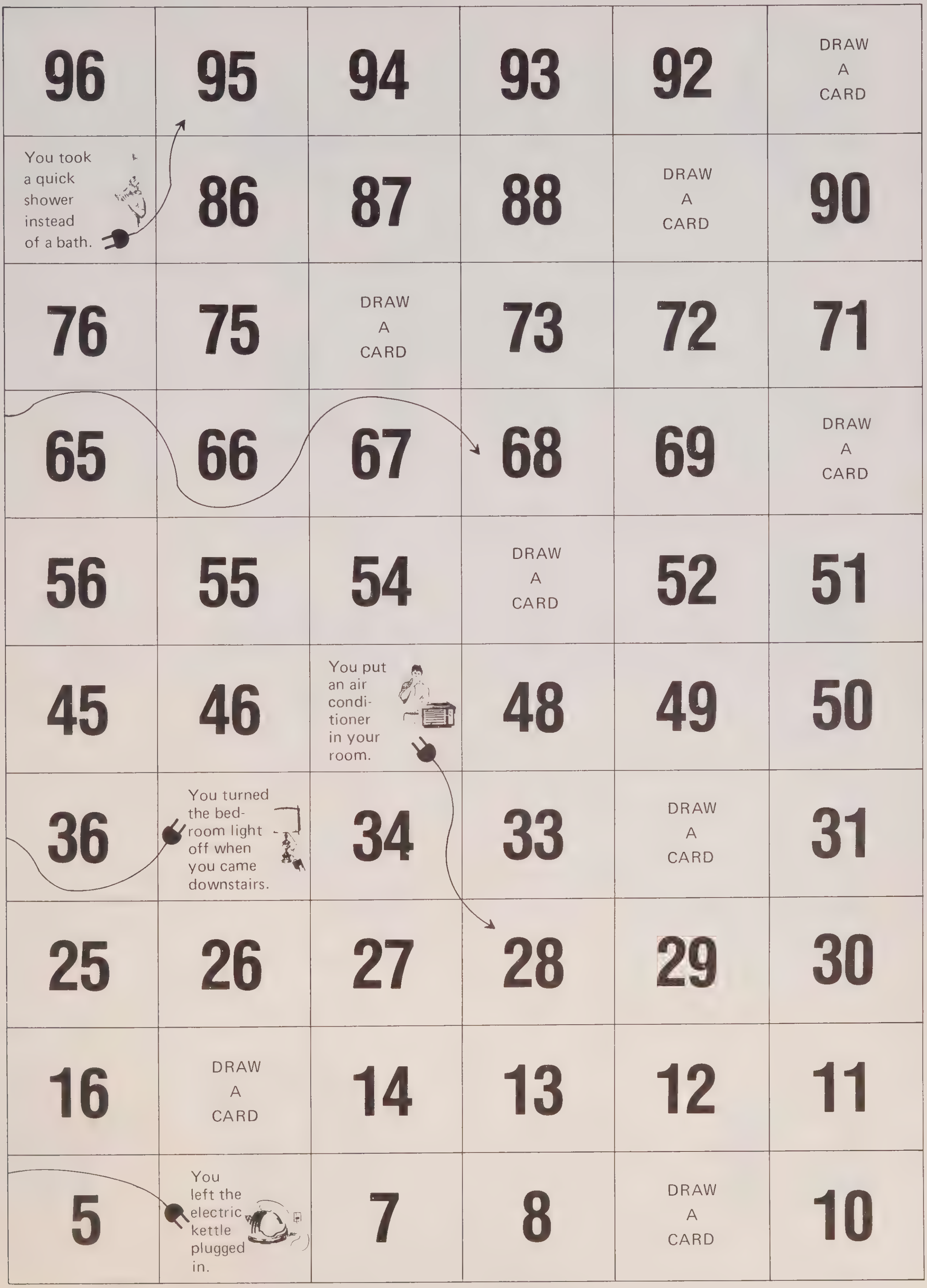


Cut out markers and paste on cardboard circles.

Cut along this line and paste onto a piece of cardboard



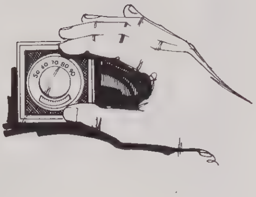
	99	You left the hot water tap dripping.	97
81	82	DRAW A CARD	84
80	DRAW A CARD	78	77
61	62	You allowed the dishes in the dishwasher to "air dry".	64
60	59	58	DRAW A CARD
41	42	DRAW A CARD	44
40	39	38	37
21	22	23	DRAW A CARD
You stopped your family from buying an electric toothbrush.	19	18	17
1	2	DRAW A CARD	4



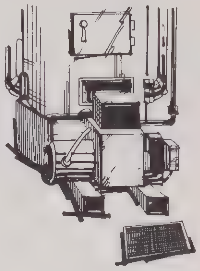
96	95	94	93	92	DRAW A CARD
You took a quick shower instead of a bath.	86	87	88	DRAW A CARD	90
76	75	DRAW A CARD	73	72	71
65	66	67	68	69	DRAW A CARD
56	55	54	DRAW A CARD	52	51
45	46	You put an air conditioner in your room.	48	49	50
36	You turned the bedroom light off when you came downstairs.	34	33	DRAW A CARD	31
25	26	27	28	29	30
16	DRAW A CARD	14	13	12	11
5	You left the electric kettle plugged in.	7	8	DRAW A CARD	10

Drawcards

Your father adjusted the thermostat to a cooler temperature at night.



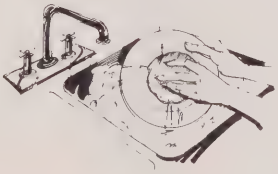
Your father changed the furnace filter, thus helping the motor to work more efficiently.



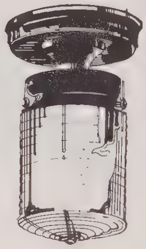
You took a bath using lots of hot water instead of taking a shower.

Your mother hung the laundry outside on the line to dry instead of using the dryer.

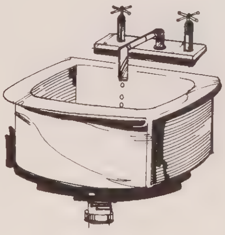
You washed the supper dishes in the sink instead of using the dishwasher.



You remembered to turn off the hall light when you left your room.



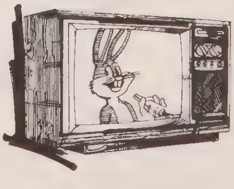
You turned off the dripping hot-water tap.



You took a shower instead of your usual bath.

You used the hair dryer instead of a towel to dry your hair.

You left the TV on and no one was watching it.



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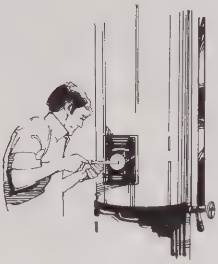
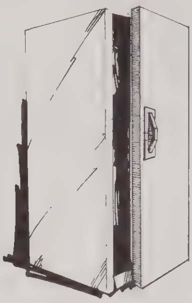
Drawcards

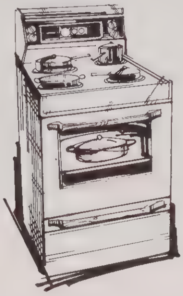
Your father adjusted the thermostat on the hot water heater to a cooler temperature.



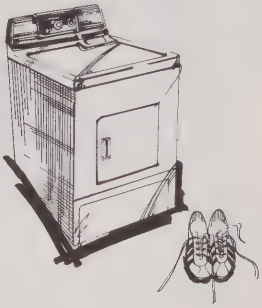
You left the refrigerator door open.



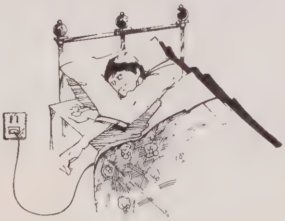
You used the oven and all four burners to make supper.



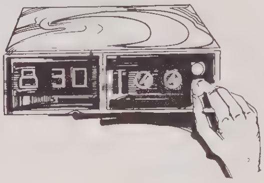
You used the clothes dryer to dry your running shoes.



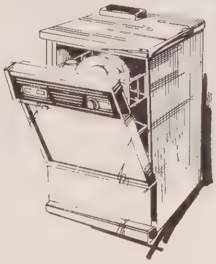
You were too lazy to get another blanket, so you used the electric one.



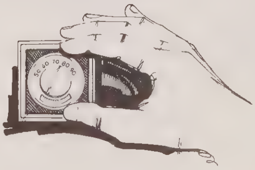
You left the radio on when you went to school.



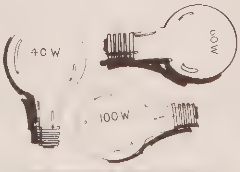
You washed only half a load of dishes in the dishwasher instead of in the sink.



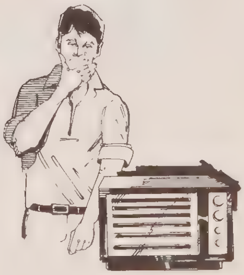
You turned the thermostat up instead of getting an extra sweater.



Your father changed some of the electric light bulbs from 100 watts to 60 or 40 watts.



You asked your parents to buy you an air conditioner for your room, because you said you can't "stand" the heat.



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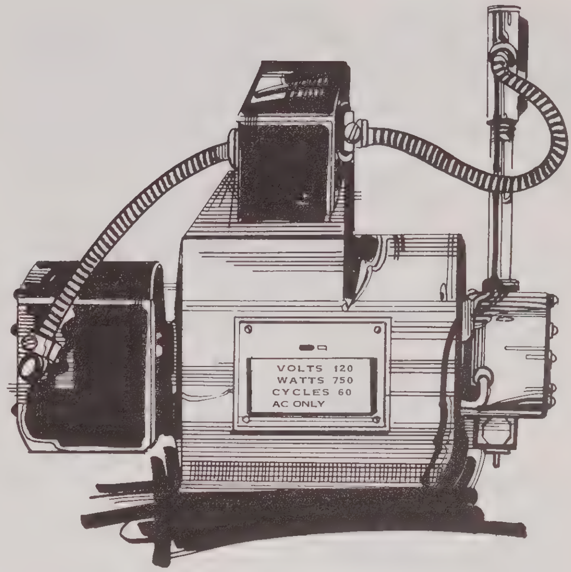
2. Electrical Power – Energy and Accounting

Introduction

It is important to know the "*power* rating" or the *rate* at which an electric device uses energy. The activities and charts in this section will allow students to power rate the majority of residential devices in a rural or urban setting. A special activity shows how the meter can be used to measure the power of a device directly.

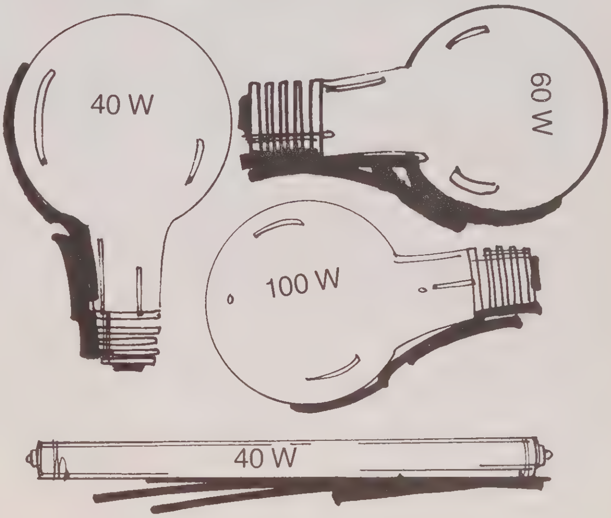
The *energy* used by a device depends on the rate of use and the time it is on. Activities are included to show how to calculate the energy converted by any or all devices over a day, week, month, or year, and appropriate flow charts are developed.



Power Ratings of Electrical Devices

Power. *The rate at which energy is converted by an electrical device.*

In order to determine just how much energy is used by an electrical device, it is necessary to know first the *rate* at which the energy is used. Does a light bulb use more or less energy in one hour than a refrigerator? To answer this question, it is necessary to know the "power rating" of the device. A 100 W light bulb, for example, uses 100 J of energy each second that it is on. *One watt is, by definition,* 1 J/s (one joule per second). The "wattage" or "power rating" of any device can be determined (or estimated – as a last resort) one way or another.



★ Determine by inspection the power rating of as many of the electrical devices in your home as possible. Concentrate first on those you consider to be the major users of electrical energy. If you get stuck, look in catalogues for similar devices or estimate from the table(s) provided. Here are some hints to help you with this activity:

1. *Motors.*

– Ignore all the numbers except the wattage rating. This number is the key to energy consumption.

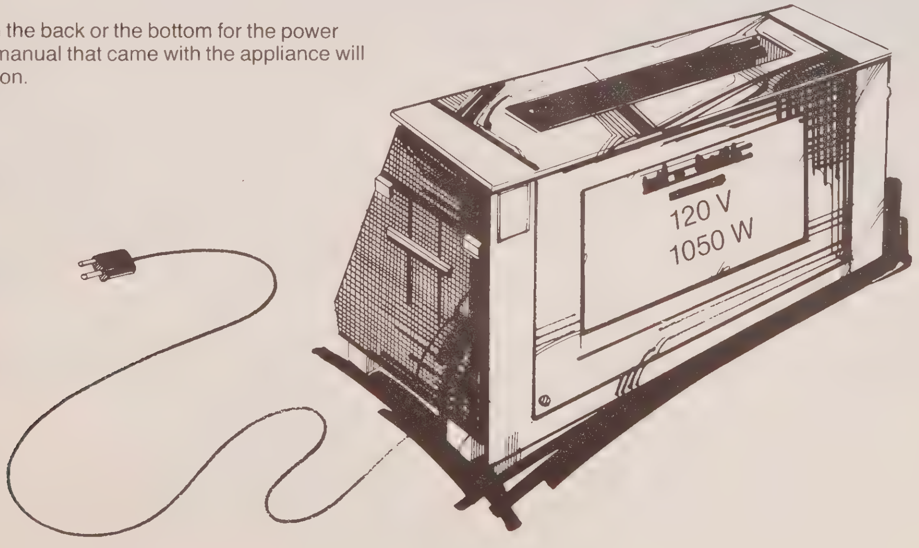
– Oil furnaces have two motors, one to inject oil and another to circulate the air or water.

– If the motor's power rating is in horsepower, convert to watts (see the tables in section 7).

– Small motors found in the home will probably be in fractions of a horsepower – $^1/_2$, $^1/_4$, $^1/_{16}$, or $^1/_{20}$.

2. *Light bulbs.* Power ratings are printed on light bulbs, e.g., 20 W, 40 W, 60 W, 100 W, 150 W, etc. Watch out for small ones like night and Christmas-tree lights.

3. *Appliances.* Look on the back or the bottom for the power rating. The instruction manual that came with the appliance will also have this information.



Calculating Wattage

Note. Some appliances require that you calculate the watts used from the voltage and current. The voltage is measured in volts (V) and the current in amperes (A). For example, in an electric kettle the voltage is 120 V and the current 12 A. In this case, multiplying the voltage by the current will give the power used in watts.

$$120\ \text{V} \times 12\ \text{A} = 1440\ \text{W or } 1.44\ \text{kW}$$

That is, power in watts = voltage in volts x current in amperes.

In most cases, this formula will not have to be used, but it is useful to know it just in case. In your home nearly everything uses 120 V, and the current drawn may be stated on the back of the appliance. Special high-energy-consuming devices, such as stoves, hot-water heaters, and clothes dryers, usually use 240 V rather than 120 V.

Tables 3.4 and 3.5 show the average wattage and the approximate monthly kilowatt hours used by most common residential appliances and farm equipment. The monthly energy use in kilowatt hours given in the tables will be explained in later activities.

Table 3.4

Average Power and Energy Conversion for Residential Electrical Appliances

Appliance	Typical Power Rating (W)	Monthly Energy Conversion (kW·h)
Cooking and Food Preparation		
Range (standard)	12 500	100
Range (self-cleaning cycle only)	3 200	4
Dishwasher	1 300	18
Oven — electronic	1 450	22
Kettle	1 500	12
Frying Pan	1 150	16
Broiler	1 400	10
Coffee maker	900	6
Hot Plate	1 320	8
Deep Fat Fryer	1 500	7
Barbecue Grill	1 350	5
Food Waste Disposer	450	3
Toaster	1 150	3
Grill (sandwich)	1 160	3
Waffle Iron	1 120	2
Carving Knife	90	1
Food Blender	390	1
Food Mixer	125	1
Can Opener	175	1
Mixer (hand)	100	2
Mixer (table)	125	2
Rotisserie	1 400	2
Incandescent lighting		
Table Lamp (tri-light)	100	8
Dining Room Fixture (5 lamp) Chandelier etc.	300	9
Ceiling Fixture (single lamp)	60	2
Ceiling Fixture (3 lamps)	120 total	3
Fluorescent lighting		
4/ft. single lamp	50	7
4/ft. two lamps	100	15
Miscellaneous		
Clock	2	1
Power Saw	275	1
Floor Polisher	300	1
Lawn Mower	1 500	3
Sewing Machine	75	1
Vacuum Cleaner	800	4
Hedge Trimmer	125	1
Block Heater	500	40
Drill	300	1
Furnace Fan (oil or gas)	250	100
Oil Burner	260	50
Home Entertainment		
Radio — tube type	50	8
Radio — solid state	5	1
Hi-fi — tube type	115	10
— solid state	30	6
Television (black and white)	200	30
Television — colour	330	40
Comfort and Health		
Room Air Conditioner 6 000 BTU/h	935	60-400
Room Air Conditioner 9 000 BTU/h	1 400	90-600
Fan (portable)	115	4
Hair Dryer (portable)	350	3
Heat Lamp (infra-red)	250	1
Heater (portable)	500-1 500	varies with wattage and use
Heating Pad	65	1
Humidifier (portable)	100	10
Shaver	15	1
Sun Lamp	280	1
Tooth Brush	10	1
Dehumidifier	350	15
Bed Blanket	180	10
Laundry		
Clothes Dryer	4 800	80
Iron (hand)	1 000	12
Clothes Washer (automatic)	500	8
Clothes Washer (non-automatic)	300	5
Water Heater	4 500	500
Food Preservation		
Food Freezer (15 cu. ft.)	335	75
Food Freezer (frost free 15 cu. ft.)	425	90
Refrigerator Freezer		
non-frost free (12 cu. ft.)	300	100
frost free (12 cu. ft.)	500	150

Source: Ontario Hydro

★ Power Ratings of Electrical Devices

– Make a list of each and every electrical device, including night lights, bathroom fans, tools in the basement, bulbs in the closets, etc. Check the list with your family. List the power ratings or wattage beside each device, estimating where necessary.

– Don't feel badly about omitting power ratings from your list if you can't find or calculate them.

– Check with other students, and look for lists of power ratings in newspapers and reference books.

– Don't be afraid to make an "educated" guess at the wattage.

Table 3.5

Estimated Average Energy Used by Farm Electric Equipment — February 1975 (Converted to metric)

Equipment	Unit Amount	Energy Use kW·h
General		
Baler	per tonne	3
Corn shellers (1 to 2 kW)	per tonne	3
Corn ear crusher	per tonne	5
Conveyor — auger	per 10 m^3	1
Elevator	per tonne	0.2
Elevator — auger	per 10 m^3	3
— bucket	per 10 m^3	1
Ensilage — cutter	per tonne	1.5
— blower	per tonne	1
Feed grinder (gen.)	per tonne	11
Feed mixer (gen.)	per tonne	1
Feeder automatic	per tonne	2
Fence — electric	per month	7
Grain dryer — no heat	per cubic metre	40
— heated	per cubic metre	8
Hay dryer — no heat	per tonne	44
— heated	per tonne	14
Silo unloader — grass	per tonne	4.5
— corn	per tonne	2.8
Soil heating cable	per square metre per month	30
Water pump — shallow	per 10 m^3	2
— deep	per 10 m^3	4
Waterer, frost free	per year	800
Dairy		
Cream separator	per month	3
Litter cleaner	per cow per month	1.5
Heating milk house		
— floor cable only (3 kW)	per operating day	8
— space heater only (3 kW)	per operating day	10
Milk cooler	per 100 kg	3
— can	per 45 L (one can)	1
— bulk	per cow per month	11
Milking machine	per cow per month	2
— with pipeline	per cow per month	3
Ventilator	per cow per month	3
Water heater	per cow per month or	7
	per 100 L	5.5
Water fountain (auto)	per cow per month	1

Equipment	Unit Amount	Energy Use kW·h
Swine		
Brooding (infra-red)	per litter	40
Farrower (floor cable)	per sow farrowed	30
Feeder	per pig per month	1
Feed grinding	per pig per month	0.3
Ventilator	per pig per month	1
Water fountains (auto)	per pig per month	0.5
Poultry		
Brooder	per chick	1
Egg cooler	per month or	25
	per layer per year	1
Egg washer	per 2000 eggs	1
Feeders (auto)	per month or	20
	per layer per year	0.3
Feed grinder	per tonne or	5.5
	per layer per year	0.1
Scalder	per 100 birds	4
Ventilator	per bird per month	0.4
Farm Lighting		
Arc welder	per month	5
Battery charger	per battery charge	2
Dairy barn	per month	80
Drill press, lathe, grinder, saw	per hour of use	1.3
Farm shop	per month (total use)	10 to 15
General barn	per month	10
General yard	per 100 W per month	20
— all night (auto)	per 100 W per month	35
Milk house	per month	35
Poultry house	per 100 hens per month	15

Source: Ontario Hydro

Using Your Meter to Measure Power

You will notice that your meter has a flat metal plate which is circular and rotates. There is a black mark on the plate so that you can count or time the revolutions. The frequency of rotation, usually measured in revolutions per minute (r/min), is related directly to the power being used at the time.

On the face of the meter you will notice a marking such as KH6. This is known as the *meter constant;* it allows you to calculate the power in watts that is being recorded by the meter. The relationship is:

$$P(\text{watts}) = (\text{r/min}) \times 60 \times \text{KH}$$

the number of rotations of the plate in one minute (Use a watch and count them.)

the number of minutes in one hour

the meter constant

For example, if you counted two revolutions of the plate in one minute, and the meter constant was 6, then the power reading would be: $P(\text{watts}) = 2 \times 60 \times 6 = 720$ W.

Run a Test

★ First, pick a time of day when only a few electrical devices are on and measure the power being used. Next, try it when the stove, TV, etc., are on (perhaps just before supper). These readings are the power totals made up of all the devices that are on at the time of measurement.

Measuring the Power of a Specific Device

★ 1. Choose a time when few appliances are in use, then make the plate *stop* rotating by shutting off everything electrical. Don't forget things like night lights, the refrigerator, fans, and the hot-water heater (if electric). The hot-water heater should have a switch on it; if not, turn it off at the fuse box.

Note: *It is also possible to do this by shutting off the circuit breakers or by unscrewing the fuses in the main box. (This should* not *be done, however, unless you feel confident of what you are doing, or have the assistance of a parent.) This requires too that you know to which circuit the device you are interested in is connected.*

2. When the plate has stopped, watch it for a good minute. It may still be turning slowly. (Is the electric clock still plugged in?)

3. Now turn on one device, or more, for which you *know* the power rating, for example, three 100 W bulbs. Using the sweep second hand of a wrist watch (or better yet a stop watch), determine the time for one revolution of the disc. To check, turn on six 100 W lamps and the period of rotation should be one-half (i.e., the disc rotates faster). Try it for ten 100 W lamps (if there are that many). This is 1 kW. If you know the wattage of a certain device (e.g., the toaster), run it by itself and measure the time of the disc rotation.

4. For each of the devices or combinations used in this way, complete the following chart:

Table 3.6

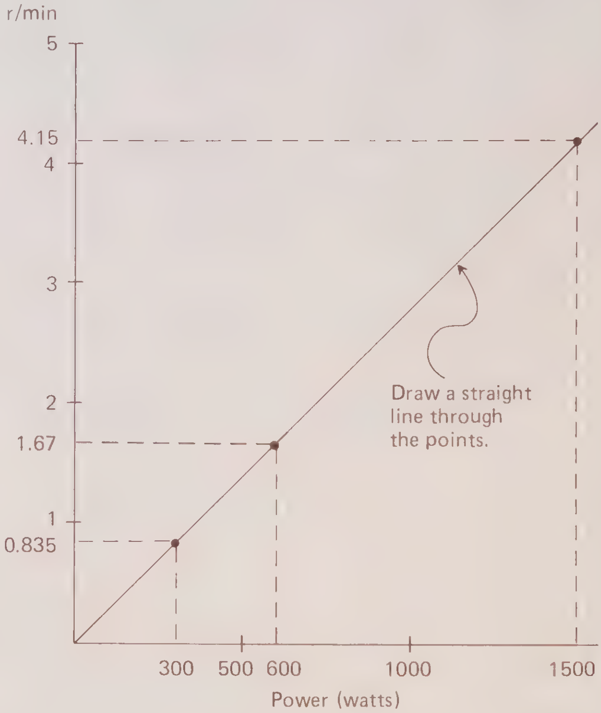
Devices	Power (Watts)	Time for 1 Revolution (in seconds)	Revolutions Per Minute
3 lamps	300	72	.835
6 lamps	600	36	1.67
Kettle	1500	14.5	4.15

Note: (i) Revolutions per minute = 60 ÷ time for one revolution in seconds.

(ii) if the voltage is not 120, your findings and results may be slightly out of line.

5. Draw a graph of your results; it might look like the one shown below. Check your results with those of others in your group or class and repeat your experiment if you think there are errors. Remember, the points on the graph must be done one at a time. The more points over a larger range, the more useful the graph will be.

Figure 3.5



Draw a straight line through the points.

Measuring Power Ratings

★ You can now measure the wattage of any device in your home – TV, radio, fan, motor, etc. – by:

1. making sure everything in the house is off (disc stopped);

2. turning on only the device you are interested in and measuring the time it takes for the disc to rotate once, then calculating the revolutions per minute (r/min);

3. determining the wattage by using the graph or the meter constant.

★ The data collected in the previous activity can be used to check or determine the meter constant (KH), since

$$KH = \frac{\text{watts}}{(\text{r/min}) \times 60}$$

Energy Accounting

The previous activities have shown you that each device uses energy at its own rate. The total energy it converts, however, depends not only on this rate (the power), but on the length of time you use the device.

The following activities will introduce you to methods for calculating the energy used by any device or combination of devices. In this way, you can monitor the electrical energy your home converts in any period of time from an hour to a year.

If you can determine, estimate, or measure the power rating of a device, all you have to do is measure or estimate the time it is on and then multiply in order to find out the amount of energy converted.

Electrical energy is sold by the kilowatt hour (kW•h) used. One kilowatt hour is the same as 3.6 MJ. A device that has a power rating of 1000 W (1 kW) when used for 1 h converts 1 kW•h or 3.6 MJ of electrical energy to other forms. To calculate the energy in kilowatt hours, just multiply the power of the device *(expressed in kilowatts)* by the time *(expressed in hours)*, i.e., $E = P \times t$. For example, a 150 W light bulb left on for 20 min uses

$$E = \frac{150}{1000}\ \text{kW} \times \frac{20}{60}\ \text{h} = 0.150 \times {}^{1}/_{3}\ \text{kW•h} = 0.050\ \text{kW•h}$$

$$= 0.050\ \text{kW•h} \times 3.6\ \text{MJ/kW•h}$$

$$= 0.18\ \text{MJ}$$

★ Use this method to determine the energy converted by:

1. a 100 W bulb used for 10 h

2. a 1500 W heater used for 3 h

3. a 3.0 kW hot-water heater used for 8 h

4. two 40 W bulbs used 8 h/d for 30 d

5. a 1000 W toaster used 5 min/d for 144 d

6. a furnace fan of 300 W operating for 20 min of every hour in the day for a month

Finding Total Energy Use for a Year

★ Develop the type of chart shown in table 3.7 for any device. Start with the large converters of electrical energy – the "major" appliances.

★ If you wish to determine the energy used on a monthly basis, just divide the annual amount by twelve. The light bulb in the chart would use 5 kW•h per month on the average. This activity can be done with every electric device in your home or school. Some average monthly figures for energy used are shown in tables 3.4 and 3.5 given earlier. You can now determine your own values.

★ Develop table 3.8 for all the electrical appliances or devices in a specific room at home or at school. Review earlier activities so that you produce realistic values.

★ Using the results of the previous activity, summarize the ways in which energy use can be reduced. Complete an energy analysis of each room in your home. In school, this could be done as a class project.

Table 3.7

Energy Record — Individual Device

Device	Power (watts)	Power (kilowatts)	Approximate Time Used (hours per day)	Approximate Number of Days Used Per Year (days)	Total Time Used Per Year (hours)	Total Energy Used Per Year (kilowatt hours)
Light	100	0.100	3	200	600	60

Table 3.8

Energy Record — Room Analysis

Room — Master Bedroom Total kilowatt hours per month ____ per year ____					
Device	**Power (kilowatts)**	**Use (hours per day)**	**Use (day, month or year)**	**Energy (kilowatt hours per month)**	**Energy (kilowatt hours per year)**
Radio					
Light					
Electric clock					
Electric blanket					
etc.					

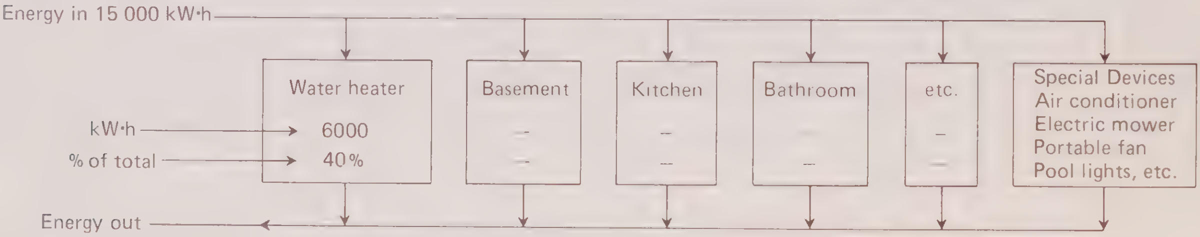
★ Develop a room-by-room flow chart of energy use in your home for one year. Figure 3.6 is an example.

Another way to look at electrical-energy conversion in the home is by the *type* of conversion taking place. This is another way of organizing the system components.

★ Develop an energy flow chart similar to that in the previous activity, but organized by category of *principal* energy conversion. The type of chart you will end up with will be similar to figure 3.7. What obvious conclusions does this chart suggest?

Figure 3.6

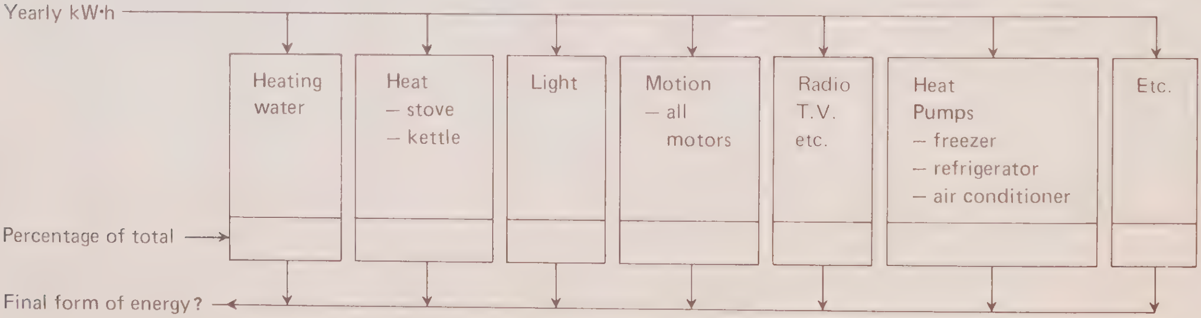
Electrical Energy Flow Chart—Room Components



★ Should the energy output be 15 000 kW·h? What type(s) of energy is it? Where does it end up?

Figure 3.7

Electrical Energy Flow Chart — Principal Conversion



3. Converting Electrical Energy in the Home

Measuring the Energy Used by Appliances

Note: In this section, some activities ask you to determine the energy used by a certain appliance over a specific length of time. In the cases where you control the device, this is not too hard to do. The ones that give difficulty are those that go on and off automatically: the refrigerator, freezer, furnace fan and motor, electric water heater, etc. These are some of the major users of electrical energy. There may be a chance that electrical-utility suppliers will agree to place portable metering equipment that you can observe on specific pieces of equipment during the time that these home activities are going on.

★ Perhaps someone in the class, or the teacher, could be assigned to contact the local electrical-utility office when the home assignments are being given out. The utility would naturally resist installing large numbers of meters, but might be interested in selecting two or three typical homes for evaluation in the interest of energy conservation.

The activities in this section have examined the flow of electrical energy through your home and you have seen how to monitor this flow and categorize the various conversions. The next section examines the specific devices that make use of electrical energy.

Introduction

The activities in this section deal with the variety of jobs electricity does for us in the home.

Lighting, not necessarily the most energy-consuming but the most obvious, is dealt with first. Appliances in general are discussed, with special emphasis being placed on the hot-water heater. The topic of energy in hot water is explored more thoroughly, however, in the unit on water.

The kitchen is a major converter of electrical energy, and these conversions are worked with in the next set of activities.
The idea of "working" with electricity is extended into the area of motion and the many motors we use.

Activities on home entertainment (the TV tube!) and on heating and cooling complete the section. Air conditioning has special significance, because it is one of the main reasons our demand for electricity is increasing.

Lighting and Electrical Energy

★ Make a list of locations in our society where we use electrical lighting. This is a method of extending the length of the day in specific areas. Why does our current life style demand the use of electricity in each location on your list? Suggest one way the demand could be decreased in each area. Develop a chart similar to table 3.9.

Table 3.9

Lighting Life Styles

Lighting Location	Life Style Reason	To Reduce the Demand
Highways	Safe travel at night	Reduce speed limits to very low values, use brighter headlights on autos.

If the school has a meter to measure illumination (perhaps an exposure meter), you can measure the light intensity. The new metric unit for this is a *lux* (lx) or *dekalux* (dalx); however, the meters you will be using probably will be calibrated in foot candles.

Note: *1 dekalux* (dalx) = *10 lux* (lx) = *0.9293 foot candles*
1 foot candle = *1.076 dekalux*

★ Use table 3.10, which shows recommended illumination levels, and the meter to see if areas of your home or school are over- or under-illuminated. Draw conclusions.

Table 3.10

Light Intensity

	Area		Dekalux	Foot Candles
School	Auditoriums	— assembly	16	15
		— exhibition	32	30
	Library	— reading areas	32	30
		— study and note-making areas	75	70
	Locker rooms		22	20
	Classrooms	— science	110	100
		— study rooms	75	70
		— note-taking areas	75	70
	Corridors and stairways		22	20
Home	Dining room		16	15
	Kitchen		160	150
	Reading areas		32	30
	General lighting (conversation, entertainment)		15	11

Note: Considerable effort is now being applied to lighting design in obtaining the most efficient and effective lighting possible.

Source: Illuminating Engineering Society Lighting Handbook.

What is so special about kitchens and science classrooms?

★ Do a study of all the incandescent light bulbs in your home. How many are used for reading? Could any be replaced by others with lower wattages? Are they clean? How many of the lampshades are opaque (i.e., don't let any light through)? What is the best type of shade to use? What lights get left on when they are not really being used? What argument can be made against turning lights off in the wintertime? Is it a good one? (Complete: "Incandescent lights should be classed as providers of ? , not light!). Start your study by completing table 3.11. Indicate in the chart those locations in which the wattage could be reduced.

Table 3.11

Home Lighting Survey

Light		Power (watts)	Type (fluorescent, incandescent)	Use
Living room	# 1	100	Incandescent	Reading
Dining room	# 2	3 x 60	?	?
(Trilite)	# 3	100 (average)	?	?

★ In your home, develop a game where rewards can be given to family members who catch others in the family leaving lights on when not needed.

★ Not all of the input electrical energy is turned to light energy in a light bulb. What is produced as well? What is the efficiency of incandescent and fluorescent lights?

Light is measured in *lumens* (lm). Here is the amount of light (in lumens) that is provided by some of the most common light bulbs:

1 100 W bulb (incandescent) provides 1740 lm.
1 60 W bulb (incandescent) provides 860 lm.
1 40 W bulb (incandescent) provides 600 lm.
1 20 W bulb (fluorescent) provides 1600 lm.
1 40 W bulb (fluorescent) provides 2850 lm.

★ 1. Do you use fluorescent lights in your home? Where could they be used to advantage?

2. Do two 60 W bulbs give more light than one 100 W bulb?

3. How many lumens would two 40 W fluorescent bulbs likely produce?

4. How many 100 W incandescent bulbs would be needed to produce the same output as in number (3)?

5. What examples can you give of large-scale fluorescent lighting?

★ Most schools use fluorescent lighting. Determine the wattage of a single tube of the type used in your classroom. Determine the total wattage when all the classroom lights are on. Calculate the total energy used in kilowatt hours if they are all on for one class period. By experiment, determine the minimum needed under various conditions and develop a set of guidelines. Post these beside the light switches or on the teacher's desk. Can you keep some switches off all the time?

★ Investigate whether your school, or all the schools in your board of education, have guidelines for school lighting – for both classrooms and corridors. Invite in the head custodian of the school so you can inquire and be informed of steps being taken to reduce the amount of lighting used in specific areas.

★ During one evening, estimate the time each light you listed in table 3.11 is on. Use the data to calculate the kilowatt hours used by these light bulbs during that evening.

★ Determine the wattage of outside lights in use at your home. Develop a list of reasons for their use and from this suggest the wattages that could be used and the maximum time they should be on. How could automatic timers be used? In your opinion, could any lighting be done away with completely?

> **New Light Bulb May Last Decade, Use Little Power**
> ERDA, the Energy Research and Development Administration has awarded a $344 000 grant to the California inventor of a light bulb that lasts 10 years and saves 70% of the energy an ordinary incandescent bulb would use. The bulb, invented by Donald D. Hollister, operates on a principle similar to that of fluorescent lights except that it does not use electrodes and will screw into a conventional lamp socket. The bulb would initially cost about $10, but would more than pay for itself in electric bills saved.
>
> The grant will be used for market surveys and preparation of a plan for producing and distributing the bulbs commercially. Most of the technical problems have already been worked out.
>
> Lighting consumes about 20% of all of the electricity generated in the United States each year. More than half the nation's lighting is done with incandescent bulbs of the sort Donald Hollister hopes to replace, so that the potential energy saving from his invention is substantial. Hollister has announced that he will not sell his patents to major light bulb manufacturers if their purpose is to keep his new bulbs off the market.
>
> From R. T. Cooper, "New Light Bulb May Last Decade . . .", *Los Angeles Times*, March 6, 1976, p. 18.

★ 1. Calculate the wattages of the new bulb that would do the same job as the lights in the list you made up for your own home in table 3.11.

2. What does the last sentence in the article imply?

Another Point of View
Turning off lights has been recommended to save energy and money in the home. In this way, a reduction of 10% can be saved on the average winter consumption for lighting. However, there is also a loss of heat, since 100% of the light energy is converted to heat. The heat loss must be made up by the heating system.

★ 1. Develop, in the class or group, a continuum illustrating individual and group opinions on these facts of the relationship between light and the saving of heat energy. Is it a good or bad practice to reduce the amount of light used?

2. If all the light ends up as heat, what happens to the heat? According to this viewpoint, what is the best conservation measure in this instance?

Lighting is the most obvious use of electricity since the energy becomes "visible" – or at least some of it does. The next set of activities should enlighten you in quite another way!

Investigating Electrical Appliances

★ List the electrical appliances in your home in order of their importance to you. List separately the ones you feel could be eliminated without lowering your quality of life. In the first list, suggest alternative approaches that would be less energy-consuming.

★ Are there some appliances that could be considered to be energy conserving? List some and explain why they can be so considered.

★ What considerations should be made when members of your family purchase major electrical appliances? Ask what influences their selection of brand, size, and model. Ask whether the amount of electricity required is considered.

★ For information on your electrical appliances, collect together, in one location, the manufacturer's manual for each electrical appliance that you have – add new ones as they are purchased. The best operating principles (maximum efficiency) and power ratings should be included in these. Write away for any that are missing.

★ Make a list of those devices in your home which "overlap" on jobs the stove could do (electric kettles, frying pans, boilers, warmers, etc.). When and why are they used? In each case decide whether by using the appliance you are conserving or wasting energy.

An important activity!
★ Establish a list of the "Top 10" converters of electrical energy in your home. Include the wattage of each device and the approximate number of kW•h used per year. Refer to the lists you made in tables 3.7 and 3.8. For each of these devices, develop a list in chart form of guidelines that would, *if followed*, reduce the amount of energy converted. Try to estimate the percentage reduction in each case and the overall reduction in kW•h per year.

Gas Appliances
★ Since this unit is on electrical energy, if your appliances (stove, refrigerator, hot-water heater, etc.) use natural gas, it is easier for you to consider them along with your heating system. Be sure to separate their demands from the furnace requirements. Try to make a comparison between a gas range and an equivalent electric range as to (a) energy used, (b) efficiency of operation, and (c) cost. For appropriate energy conversions, see the tables in section 7.

Obtaining the information needed for this comparison may prove to be quite challenging for the average student, but this activity is still recommended.

Our Love for Hot Water

The use and misuse of hot water in our homes is a major area for the study of energy conservation. It has such a major role that it is dealt with in detail in Part 4 entitled "Water – Our Most Abused Resource".

The most convenient way to determine the energy involved in producing hot water is to measure the volume of hot water used and the temperature change through which it is heated. These energy calculations are done in the unit on water.

★ Determine how your water tank is heated – by electricity, oil, or natural gas. If oil or natural gas is used, include the energy analysis in with your work in the unit on space heating, since it is likely that this is also the way your house is heated. Water heated by oil or gas is also referred to in the unit on water. Remember that the amount of energy that gets into the water depends on the efficiency of operation of the gas or oil burner.

For electricity, it is assumed that almost 100% of the electrical energy is converted into heat energy in the water in the hot-water tank. For keeping just enough heat in the water and for using the hot water wisely, see Part 4.

★ Determine the power of your electric water heater and, by using the chart on page 18, estimate the number of kilowatt hours used per month and per year. Include this as a *separate* item in any electrical-energy analysis you do.

★ From Part 4 on water, determine the amount of hot water you and your family use per day, month, or year and calculate the energy required to heat it. Convert this to kilowatt hours by using the fact that 3.6 MJ = 1 kW•h. This will allow you to double-check your estimate in the previous activity.

★ Help your parents to do the following:

1. Repair any leaking hot-water taps.

2. Insulate long pipe runs between the heater and hot-water taps, where practical.

3. Adjust the hot-water thermostat to the minimum required temperature you need.

Dishwashers (and Dryers)

The tendency by many families in Canada to purchase one of these is one reason why the average per-capita rate of using both electricity *and* water is on the increase.

A typical family of four would likely do a normal day's dishes in one dishwasher load. If washing by hand, they would likely do dishes two or three times a day. It takes no more energy to do a full load of dishes in a dishwasher than to do a partial load. The figures in table 3.12 are based on energy use *per dishwashing day,* regardless of the number of dishes done.

★ Investigations:

1. Take a class survey to determine how many families have a model "A" dishwasher – today, one year ago, etc. Plot a graph. What is the trend? What does it imply?

2. If you have a model A, answer these questions. Do you really need a full drying cycle to get the dishes dry? Do you need a drying cycle at all? Does rinsing require hot water? What washing cycle should be used if possible?

3. If your family does not have a model "A", but is considering it, develop a list of "pros" and "cons" regarding its purchase.

4. Develop a list of things to do and a list of things not to do in order to conserve energy when using a dishwasher of the type currently in your home (A or B).

5. What are some methods (nice ones) of getting boring jobs done?

The Clothes Washer

The energy used in a clothes washer is mainly related to the amount of hot water used. For this reason it is included in the unit on water. The motor is electric, however, and should be included in the activity on "motors" on p. 29. Refer to the lists provided earlier, in tables 3.4 and 3.5, for energy estimates.

The Clothes Dryer

★ The next time there is a load of clothes in the dryer, pull up a comfortable chair and start watching the clock. After 15 min, open the dryer door, *wait* for the drum to stop turning, then feel the clothes (carefully, as they will be hot). Some will still probably be damp. Close the door and restart the dryer.

Do this again every 5 min until all the clothes feel dry to the touch. Look at the timer and see how much longer the dryer was set to run. Draw some conclusions and set them down as guides for preventing energy waste when using a clothes dryer. Are there some things for which you should not use a clothes dryer?

Does your clothes dryer have special drying cycles such as "permapress"? Check the manufacturer's literature to determine if these cycles are energy wasters or savers.

In the summer, why not use a solar clothes dryer?

Table 3.12

Comparison of Dishwashers

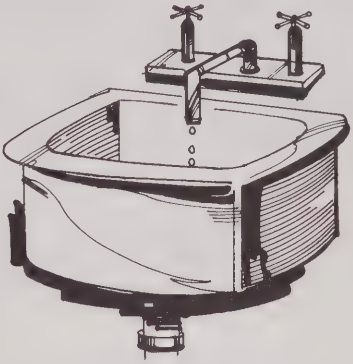
	Model A (mechanical) (1 time/day)	Model B (human) (3 times/day)
Washing and Rinsing	4.75 kW·h	1.98 kW·h
Washing	0.21 kW·h	nil
Drying	0.42 kW·h	nil
Total	5.38 kW·h	1.98 kW·h

Figure 3.8

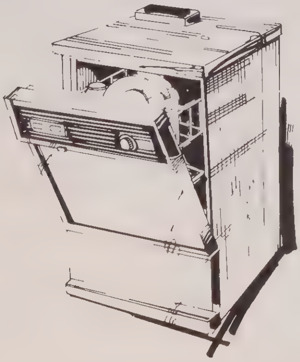
Using Hot Water

★ Each of the following 6 illustrations involves the conversion of electrical energy to heat in the water. Answer the questions printed below each sketch.

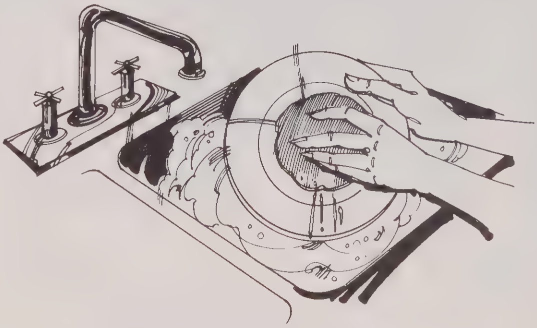
What *determines* the maximum temperature at which the hot water is kept?
What is the *minimum* temperature required in your home?



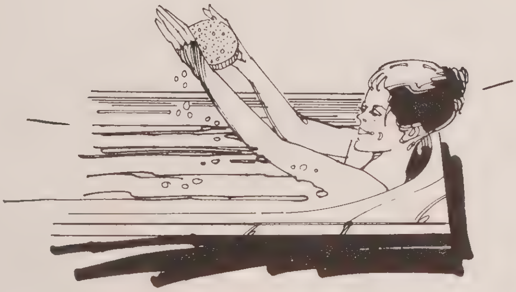
Why is it that it's usually the hot water tap that leaks?



Under what conditions does a dishwasher save energy?



Under what condition does washing dishes by hand save energy?



Under what conditions would taking a bath (versus taking a shower) save energy?

What is the maximum time needed for a decent shower?
What type of shower-head would save energy?

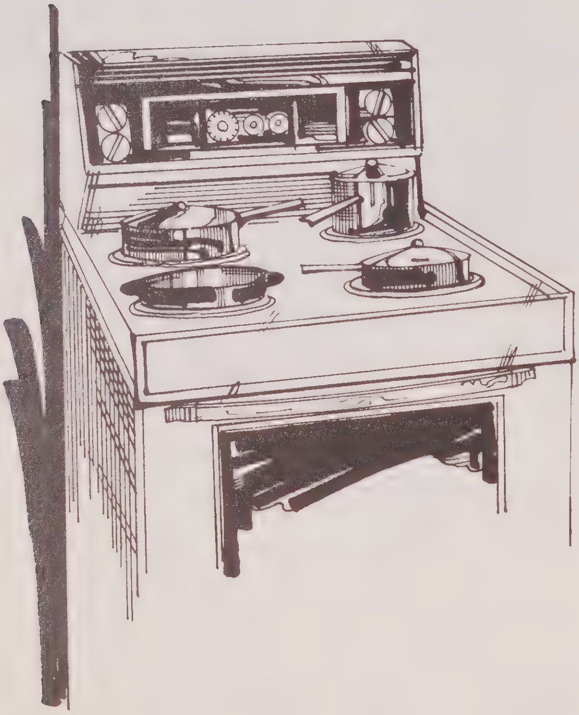
Electricity and Food

Of the many electrical appliances in our homes, the ones associated with food preparation and preservation are most familiar. Does this familiarity make you less conscious of the energy they use?

★ Your range and oven are the greatest users of energy in your kitchen. See if you can determine, by using catalogues and instruction manuals, the maximum power your stove and oven would use if everything were on full. Consider your average use over a week. Use this figure to come up with an average daily use. For an electric range it might be 3000 W for 1.5 h each day. Compare this figure with others in the class and with those listed in table 3.4 and revise your figures to get the most realistic figure possible.

★ For a week, keep track of the purposes for which energy is used (i.e., the type of cooking being done, the time of day, etc.). Devise a list of suggestions, like the ones below, one each for the oven and for the range (the stove-top elements) that, *if followed*, would save energy. Discuss them with those who use the stove.

Guidelines for Cooking With Minimum Energy Use



★ *Range*

1. Don't use too much water when cooking vegetables.

2. Use well-fitted saucepan lids. Start to boil water on "high" and then reduce to "low" or "simmer".

3. Pick a flat-bottomed pan that fits the element; keep the lid on the pan.

4. ?

5. ?

★ *Oven*

1. Use the oven for whole-meal cooking.

2. ?

3. ?

★ Discuss with your family the type of decisions made in preparing food as they may relate to energy consumption. (See Part 5, "Food for Human Energy", in reference to this.) Extend the lists above for the oven and range based on how your family uses them.

Microwave Ovens

These have not been "on the market" very long; one argument used in their promotion is energy conservation. Read what one research team found out and decide for yourself.

> Because many inquiries at the Consumers Institute question the truth of the sometimes heard statement that microwave ovens save 75% of the energy used cooking on conventional ranges, we conducted a number of actual cooking and menu tests to compare the exact energy required for conventional as well as microwave cooking.
>
> We found that microwave ovens offer the greatest savings in cooking small to medium quantities of concentrated foods such as meats, potatoes, and desserts (particularly puddings and sauces) and in heating TV dinners. Foods such as corn, broccoli, and similar vegetables require more energy to cook with microwaves than with conventional electric surface units (see table 3.13).
>
> Source: *Home Economics*, November 1975.

Table 3.13

Energy Savings: Microwave Oven Versus Conventional Electric Range

Cooked in Microwave Oven	Energy Savings
4 baked potatoes	60.7%
1 frozen TV dinner: 11½ oz. (325 g)	79.3%
Casserole: 4½ cups (1050 ml)	58.4%
Summer squash: 16 oz. (450 g)	–54.8%
Peas and celery: 3½ cups (825 ml)	–46.1%
Frozen broccoli: 10 oz. (280 g)	–30.2%

Microwave cooking energy is calculated at 2450 MHz (megahertz). The minus figures indicate that the conventional cooking method uses that much less energy than the microwave method.

Source: *Home Economics*, November 1975

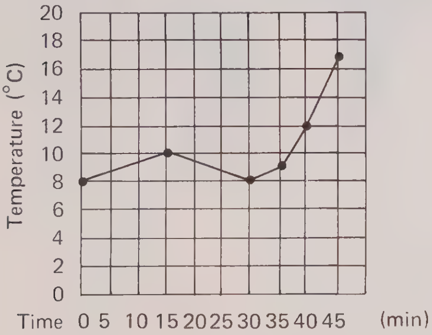
★ Post a list beside your microwave oven of advice concerning its most efficient use.

Electricity Moves Heat
In addition to heating food, we have to cool it, extracting the heat and relocating it elsewhere.

★ Put a thermometer inside the refrigerator, close the door, and wait 15 min for the thermometer to reach the inside temperature. Open the door and, working as quickly as you can, read the inside temperature. Close the door, then unplug the refrigerator's power cord from the wall outlet. Make sure that no one opens the door for exactly 15 min. At that point, open the door and take another temperature reading. Plug the refrigerator back in (its motor will probably come on) and wait another 15 min (the thermometer should be back inside). Now, unplug the refrigerator again and repeat the experiment, but with one difference. Every 5 min open the door for 30 s and read the thermometer.

★ Plot a graph similar to the one below of temperature versus time. At what rate is the temperature increasing? This temperature increase does not actually happen when the refrigerator is plugged in. What happens when the door is opened often?

Table 3.14



★ To calculate the energy used by the refrigerator you will have to estimate the total number of hours per day that it is running. (It doesn't run all the time.) (Refer to table 3.4.)

Ideas for Conserving Energy When Using Freezers and Refrigerators
★ Develop a list of ideas to be followed to conserve the energy required by the refrigerator and/or the freezer and post them on the door(s). Here is a sample list to get you started:

Refrigerator
1. Defrost before the ice reaches a thickness of 6 mm.

2. Set the control so that the temperature is not colder than necessary. Be sure the refrigerator door is airtight.

3. Don't open the door more than necessary. Locate the refrigerator away from direct warm spots and allow for free air circulation around the sides and back.

4. Allow hot foods (except meats and foods with meats in them) to cool before refrigerating.

5. Don't overcrowd: this interferes with normal air circulation.

6. ?

Why do "frost-free" refrigerators require more energy than the defrosting type? How do they work?

★ Discuss with your class or group the changes in life style over the years that have brought about this requirement to cool or freeze our food before, and in many cases after, cooking it.

Refrigerators and Freezers Are Like Heat Pumps
★ Your refrigerator and freezer are types of heat pumps. They take heat energy from one location and put it in another, using energy to do this. What does this suggest about trying to cool the kitchen off in the summer by opening the doors of these appliances? What is the difference between these appliances and an air conditioner (which is also a type of heat pump)?

Do some research in the library and find out about heat pumps.

Electric Motors Make Things Move!

Much work that used to be done by hand is now done using electric motors.

★ Go through your house and make a list of each and every motor. Don't forget the ones that are hidden (bathroom fans, refrigerator and furnace fans, lawn mower, vacuum cleaner, etc.). Do you think you will reach 20? 50? The kitchen and workshop will be great locations to find motors.

★ Determine the power of each device in your list by using the methods described earlier in this section. The power may be rated in horsepower: 1 HP = 746 W = 0.746 kW. Nearly all electric motors found in your home will be $^1/_2$ HP or less.

★ Estimate the time each motor is used and do an energy analysis for each for a year. Calculate the total energy used. What percentage of the total energy used in your home is consumed by these electric motors?

The Workshop
★ Do an energy analysis for the workshop in your home, estimating the use of energy in it over a year. What percentage of the total energy used in your home is used in the workshop? Explain how the workshop adds to your family's life style.

Relocating "Water"
The relative humidity, along with the temperature, has a major effect on how you feel. This idea is covered in some detail in the unit on space heating. Two devices that are found in many homes and that alter the relative humidity are:

1. *a dehumidifier* – usually used during the summer to dry out the warm, moist air found in basements;

2. *a humidifier* – usually used in winter to add water to the dry air in your home.

★ Determine whether your home has either or both of these devices. If so, find out their total energy consumption for the season using the methods given earlier. Refer to table 3.4 for estimates of energy used. Comment on the value obtained from using these devices: is this a good or poor use of energy?

Table 3.15

List of Electrical Convenience Appliances

Appliance	Type of Energy Derived (heat, light, motion, etc.)	Power Rating (watts)	Time Used (hours per month)	Estimated (kilowatt hours per month)

★ **"Convenience" Appliances**
Many electrical appliances are often referred to as "convenience" items. Your class or group can quickly develop a list of these items and then check off on it those that are in each of your homes. Your list may look like table 3.15, if you do an energy analysis of these appliances.

1. What conclusions can you draw from your list and the lists of others in your group or class?

2. Suggest reasons why these were and are purchased in the first place. Why do people think that they "could not do without them"?

3. Do some "convenience" items actually conserve energy if the total energy picture is considered? Pick one example and argue the case.

4. What type of energy is produced as well as and after the derived energy?

5. In many cases, although the energy consumed in the use of these items is very small, they represent a consumption of large amounts of energy. Explain why.

6. What consumer attitudes do these convenience appliances help create?

★ Do an energy analysis of an electric blanket.

Energy used per night would be: *P* x *t*

P (kW) x time (h) = ________kW•h

1. What are alternative methods of keeping warm?

2. Do they use more or less energy?

3. Estimate the energy used by the electric blanket in a year.

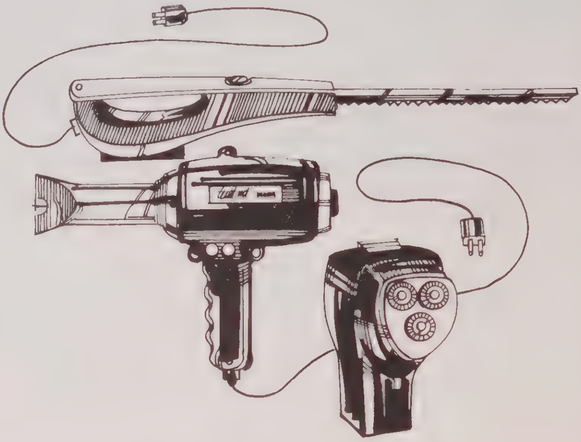
★ Do an energy analysis of a hair dryer.

Total energy per year would be:

P (kW) x time (h) to dry a head x the number of heads dried in a year - kW•h.

The best way to solve a problem is to avoid it! Suggest that your dad can conserve energy by growing a beard! (What about washing it?)

★ Can you develop a convincing argument that using an electric razor once a day over its lifetime will use less energy than if hot water is used to produce a lather with a brush? Consider also the electrical heaters that are used to prepare heated lather.



Electrically Powered Toys
★ List some electrically powered toys that function solely for recreation or entertainment. Have a class discussion to decide whether or not battery-powered items should be included. Attempt to answer for each toy such questions as: How long has it been on the market? Was it marketed to fill a need or did its appearance on the shelf, along with the advertising done for it, create its own need? If it does fill a need, can you think of alternative diversions that require less energy consumption? Consider also go-carts, ferris wheels, roller coasters, etc.

Electrical Energy and Its Role in Communications

Television

★ 1. How much television do you and your family watch each week? Keep a record on a chart like table 3.16.

Table 3.16

TV Viewing Survey

Show	Length	Viewers	Value Rating

Table 3.17

Degree days and Design Temperatures (Ontario)

Location	Design Temperature 2.5% °C	Degree Days Below 18°C
Ailsa Craig	–16	7300
Ajax	–19	7500
Alexandria	–24	8400
Alliston	–22	8300
Almonte	–26	8700
Ansonville	–32	11400
Armstrong	–39	12458
Arnprior	–27	8800
Atikokan	–34	11066
Aurora	–20	7900
Bancroft	–26	9100
Barrie	–23	8200
Barriefield	–22	7800
Beaverton	–23	8400
Belleville	–22	7709
Belmont	–16	7300
Bowmanville	–19	7600
Bracebridge	–25	8800
Bradford	–22	8100
Brampton	–18	7721
Brantford	–16	7202
Brighton	–21	7800
Brockville	–23	7900
Brooklin	–19	7800
Burks Falls	–26	9300
Burlington	–16	6800
Caledonia	–16	7200
Cambridge	–17	7600
Campbellford	–23	8100
Camp Borden	–22	8200
Cannington	–23	8400
Carleton Place	–25	8600
Cavan	–22	8200
Centralia	–16	7243
Chapleau	–35	10900
Chatham	–14	6503
Chelmsford	–26	9700
Chesley	–18	7800
Clinton	–16	7600
Coboconk	–24	8700
Cobourg	–20	7700
Cochrane	–33	11412
Colborne	–21	7700
Collingwood	–21	8400
Cornwall	–23	8200
Corunna	–14	7000
Deep River	–29	9500
Deseronto	–22	7500
Dorchester	–16	7400
Dorion	–32	10800
Dresden	–15	6800
Dryden	–34	11147
Dunbarton	–18	7400
Dunnville	–14	7000
Durham	–19	8474
Dutton	–15	6900
Earlton	–32	10792
Edison	–33	11000
Elmvale	–23	8400
Embro	–16	7600
Englehart	–32	10900
Espanola	–25	9300
Exeter	–16	7500
Fenelon Falls	–24	8600
Fergus	–19	8452
Fonthill	–14	6800
Forest	–14	7031
Fort Erie	–14	6600
Fort Frances	–32	10700
Gananoque	–22	7800
Georgetown	–18	7817
Geraldton	–35	12000
Glencoe	–15	7000
Goderich	–16	7712
Gore Bay	–23	9009
Graham	–67	11838
Gravenhurst	–25	8700
Grimsby	–15	6592
Guelph	–18	7749
Guthrie	–23	8300
Hagersville	–15	7200
Haileybury	–32	10700
Haliburton	–26	9038
Hamilton	–16	6821
Hanover	–18	8000
Hastings	–23	8200
Hawkesbury	–25	8800
Hearst	–33	11900
Honey Harbour	–23	8400
Hornepayne	–37	12066
Huntsville	–26	8726
Ingersoll	–16	7400
Jarvis	–15	7100
Jellicoe	–36	11800
Kapuskasing	–33	11560
Kemptville	–24	8338
Kenora	–33	10796
Killaloe Sta.	–28	9074
Kincardine	–16	7800
Kingston	–22	7724
Kinmount	–25	8800
Kirkland Lake	–32	11269
Kitchener	–17	7566
Lakefield	–23	8500
Lansdowne House	–39	13021
Leamington	–14	6547
Lindsay	–23	8400
Lions Head	–18	8000
Listowel	–18	8500
London	–16	7349
Lucan	–16	7395
Maitland	–23	7900
Markdale	–19	8600
Martin	–36	11600
Matheson	–32	11400
Mattawa	–29	9800
Midland	–23	8400
Milton	–17	7500
Milverton	–18	8300
Minden	–26	8900
Mississauga	–17	7000
Mitchell	–17	8076
Moosonee	–36	12723
Morrisburg	–23	8105
Mount Forest	–19	8800
Muskoka Airport	–25	8758
Nakina	–34	11969
Napanee	–22	7600
Newcastle	–19	7600
New Liskeard	–32	10700
Newmarket	–21	8000
Niagara Falls	–15	6881
North Bay	–27	9677
Norwood	–23	8300
Oakville	–17	6700
Orangeville	–20	8526
Orillia	–24	8463
Oshawa	–19	7600
Ottawa	–25	8693
Owen Sound	–18	7762
Pagwa River	–34	11599
Paris	–16	7400
Parkhill	–15	7300
Parry Sound	–23	8480
Pembroke	–28	9100
Penetanguishene	–23	8400
Perth	–24	8300
Petawawa	–29	9200
Peterborough	–23	8300
Petrolia	–15	6900
Picton	–21	7500
Plattsville	–17	7600
Point Alexander	–29	9500
Porcupine	–33	11400
Port Burwell	–14	7000
Port Colborne	–14	6700
Port Credit	–17	6800
Port Dover	–14	7046
Port Elgin	–17	7800
Port Hope	–20	7700
Port Perry	–21	8100
Port Stanley	–14	7000
Prescott	–23	7500
Princeton	–16	7400
Raith	–34	11100
Red Lake	–34	11400
Renfrew	–27	8787
Ridgeway	–14	6600
Rockland	–26	8800
St. Catharines	–15	6537
St. Marys	–16	7600
St. Thomas	–15	7073
Sarnia	–14	7061
Sault Ste. Marie	–26	9500
Schreiber	–34	11131
Seaforth	–16	7800
Simcoe	–15	7100
Sioux Lookout	–34	11313
Smiths Falls	–24	8300
Smithville	–15	7200
Smooth Rock Falls	–33	11500
Southampton	–17	7811
South Porcupine	–33	11400
South River	–26	9500
Stirling	–23	7976
Stratford	–17	7900
Strathroy	–16	7200
Streetsville	–17	7500
Sturgeon Falls	–27	9500
Sudbury	–26	9600
Sundridge	–26	9400
Tavistock	–17	7700
Thames ord	–16	7400
Thedford	–15	7100
Thunder Bay	–31	10405
Tillsonburg	–15	7200
Timagami	–30	10200
Timmins	–33	11400
Toronto	–17	6827
Trenton	–21	7510
Trout Creek	–27	9600
Trout Lake	–38	14040
Uxbridge	–22	8170
Vanier	–25	8600
Vittoria	–14	7100
Walkerton	–17	7647
Wallaceburg	–14	6668
Waterloo	–17	7566
Watford	–15	7000
Wawa	–36	10334
Welland	–14	6691
West Lorne	–15	6900
Whitby	–19	7500
White River	–39	11674
Wiarton	–17	8063
Windsor	–14	6579
Wingham	–17	7800
Woodstock	–16	7542
Wyoming	–15	7000

Adapted from *Canadian Standards Association, 1975*

★ 2. What role does TV play in your life style? What are its values?

3. What are some simple rules to ensure that TV-viewing will not waste energy?

4. Calculate the total number of hours of viewing time for the week and discuss with your family if this should be cut down. What would you do with the extra time? Would these alternatives be more energy expensive?

5. Calculate the energy used. You will have to consider the following:

a) Is your TV a colour set or a black-and-white one?

b) Is it an "instant-on" type? (What does this mean, and is it necessary?)

c) Is it manual or remote control?

Estimate the power used from table 3.4 if you cannot get it from the back of the set or the manual, or if it is not feasible to measure it using the electric meter as described earlier in section 2.

Radios, Stereos, Tape Decks

★ Determine the power of each, estimate the time they are on each day (or week), and calculate the electrical energy used.

Be careful not to confuse the power output with the electrical power input required to operate them. If you can obtain both, see if you can calculate the efficiency of the conversion. What happens to the sound energy produced? How many hours are these devices on when nobody is really listening?

Some Things for You to Think About

★ 1. Who supplies the electricity to operate the telephone?

★ 2. How is electricity involved in all the printed material brought into your house (newspapers, books, magazines, etc.)? What is done with these after use?

Heating With Electricity

Space heating using electricity is neat and clean. Remember, however, that it was another form of energy that produced the electricity at the generating plant. Should electric heating be promoted if we consider the production and distribution as well as the final conversion?

In 1976, approximately 8% of Ontario houses were heated electrically.

★ If your home is partially or completely heated by electricity, determine the total connected load in kilowatts. The connected load is approximately equal to the heat loss. Use the formula below to calculate the number of kilowatt hours used for heating for a complete year in your home.

$$\text{kW•h} = \frac{\text{heat loss (kW)} \times \text{degree-days} \times \text{C}}{\text{design temperature difference (°C)}}$$

Notes: 1. Degree-days and design temperature may be obtained from table 3.17.

2. "C" is the experience factor; it is usually 16, but, at any rate, it may be obtained from your local electric utility company.

Comparing Heating Efficiency

★ Although producing heat with electricity is very efficient on location, the total efficiency is much less when you consider the transmission and production of the electricity in the first place. However, the same is true for other heat sources too. Compare the overall efficiency (from production to end use) of oil, gas, and electricity when used for space heating. Consider all sources of energy used for space heating. Consider all sources of energy used for producing electricity. The data at the end of this part and figure 3.9 will be useful for these calculations.

Space Heating With Electricity: Pros and Cons

★ In your class or group, discuss the pros and cons of using electricity for space heating. Consider the following opinion expressed after reading an article favouring electrical heating.

> Before too many of your readers rush out to buy electric heating systems . . . a few points should be clarified.
>
> In this case the local benefits of a clean, flexible heating system with low installation costs become translated into increased system costs in the form of more power plants located on less and less suitable sites. Most of our hydro potential is, or soon will be developed, and was developed to satisfy demands that did not include electric heating. Increased demands for electric heating lead to increased demands for electricity capacity (electric heating will add to the peak demand which currently comes in December or January) and in the future this capacity will be largely thermal: coal, nuclear and less likely oil and gas. And in this case the absurd inefficiency of electric resistance heating (less than 30%*) will have important ecological impacts.
>
> From a letter to the editor by R. Joel Rahn, *Globe and Mail*, July 5, 1976.
>
> *This is the total efficiency including production and transmission.

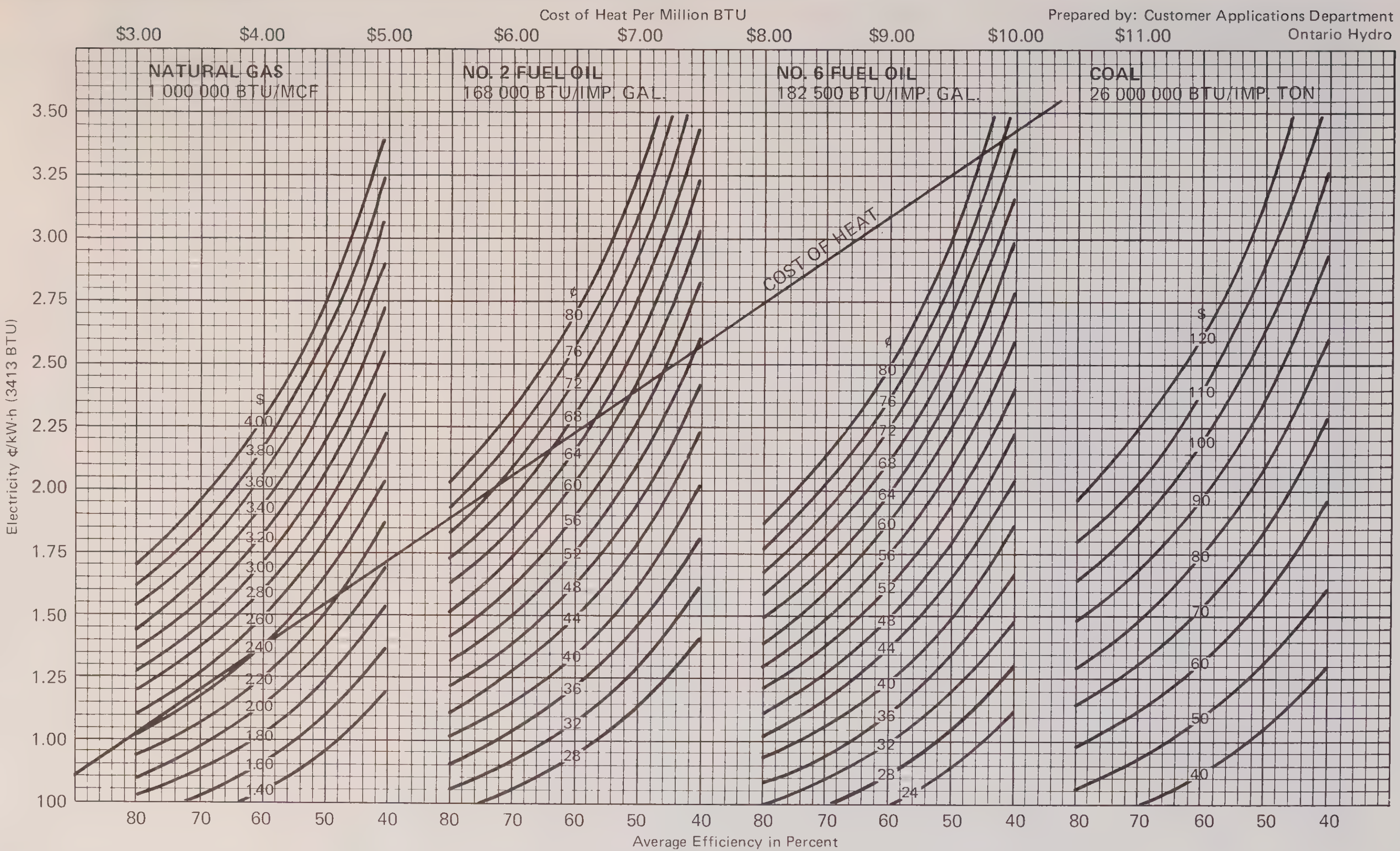
Portable Space Heaters

★ Many homes make use of electric portable space heaters. Baseboard heaters, portable or fixed, could also be considered here. If your home uses these, determine their power (kilowatts) and estimate the hours per year they are used and the total kilowatt hours of energy converted. How would this type of heater best be used to conserve energy? Can you suggest an alternative to portable space heaters?

Turning Down the Thermostat at Night

★ 1. From information given in the space-heating unit, explain why turning down the thermostat at night saves electrical energy, even if your home is heated by oil or natural gas.

2. What other types of energy does it save?



Prepared by: Customer Applications Department
Ontario Hydro

Instructions

To compare fuel costs: Draw a horizontal line across the graph through the factors known about any fuel.

These factors are: cost per unit of fuel and efficiency of heat production for the device in which the fuel is used.

Where the horizontal line intersects the "cost of heat line" read up to find cost per million BTU in dollars.

All fuels through which the line passes will produce heat at the same cost.

Any fuel cost lying above this line is more expensive and any fuel cost below this line is less expensive.

Note: This figure reflects 1975 costs only. Higher figures are currently in effect.

Example #1

Assume current electricity costs are 2.0 cents/kW·h. Draw a horizontal line through 2.0 cents electricity. The cost of heat is $5.86 per million BTU. All other fuels through which the line passes will produce heat at the same cost.

If the average annual efficiency of a gas furnace is 50% the equivalent gas price is $3.50 per MCF.

In the same way, at 60% efficiency, the equivalent price for #2 oil is 59 cents/Imp.gal., for #6 oil, 64 cents/Imp.gal. and for coal, $91 per ton.

Example #2

Coal purchased at $50 per ton is currently being used with 40% efficiency. Addition of air to air heat recovery to preheat combustion air and products will improve the efficiency to 60%. Calculate the cost of heat with and without heat recovery equipment.

Draw a horizontal line corresponding to $50/t on coal and 40% efficiency. From where it intersects the "cost of heat line" read the cost of heat as $4.75 per million BTU. Similarly corresponding to 60% efficiency read the cost of heat as $3.20 million per BTU.

Note: It may be necessary to refer to table 5 on p. 52.

Figure 3.10

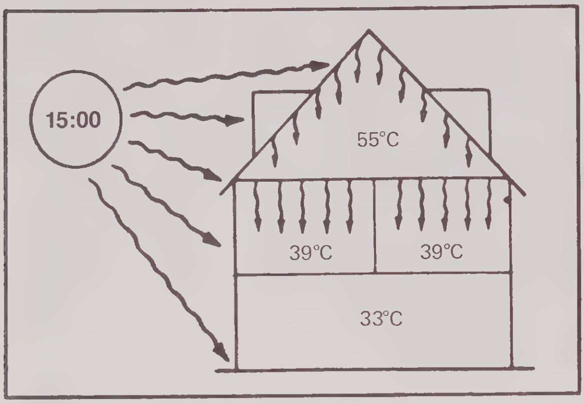
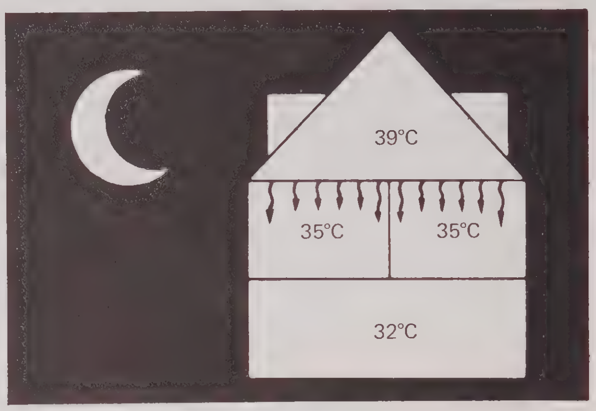


Figure 3.11



Cooling With Electricity

In the residential and commercial sectors of our society, the move towards "air conditioning" probably represents the largest single factor in our increased use of electrical energy. Let's investigate!

If you've ever been up in your attic on a midsummer day, you already know just how hot it can be. When it's 35°C outside, the temperature in an attic can reach as high as 55°C.

The first illustration above shows the heat built-up that results from the direct rays of the noon-day sun. Notice how attic heat radiates downwards into the living areas.

The second illustration shows the same house after sundown. There has been some moderating effect due to a cooler outdoor temperature, but hot air trapped inside the attic still remains at 39°C. Radiating downwards, this trapped heat will cause discomfort in bedrooms and other living areas. As a heat wave continues, the discomfort conditions tend to worsen a little with each passing day. Some relief may be found in a basement family room, since below-grade space is somewhat protected from the sun's radiation. However, basements usually tend to be chilly and damp during the summer months. This below-grade dampness is the natural result of warm air mixing with cooler air, causing conditions of high humidity.

To cool a home during the summer months, the hot air must be removed or replaced from the attic and living space. Either fans or air conditioners may be used to dissipate the heat built-up.

Remember that the heat waves we experience in Ontario are seldom severe or of long duration. Indeed, the need for summer cooling in our province occupies only a short period of the year.

★ Survey your class and list various methods used to overcome the problem of heat. Some methods might include the use of:

1. a fan
2. an air conditioner (either located centrally or in a window)
3. a furnace circulation fan
4. a combination of the above
5. attic ventilation
6. extra soffit and roof vents

★ Discuss the above methods and try to decide which consumes the most energy and which the least, and why.

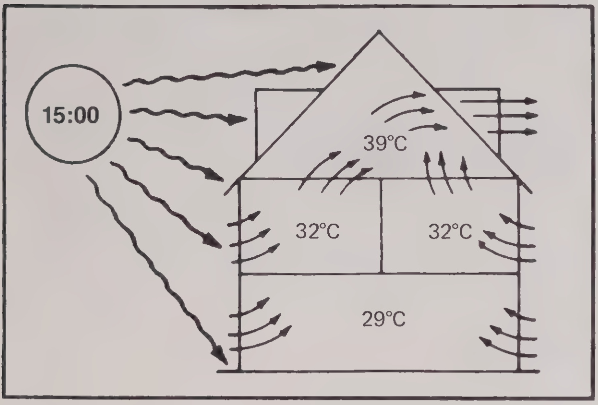
Air Conditioners

The tendency to use more air conditioners is a significant factor in the increased consumption of electrical energy in the residential sector. An air conditioner acts like a heat pump that takes heat energy from the inside of the house and puts it outside.

★ If your family has not purchased an air conditioner but plans to, determine the cooling power that will be needed. This information from Ontario Hydro will help you:

> Buying an air conditioner with the right capacity (measured in BTU's) is vitally important. When properly sized an air conditioner will keep you cool, reduce humidity and clean the air and will work at peak efficiency. A unit rated higher than you really need may lower the temperature faster but leave you cold and clammy, since it will not stay on long enough to get rid of any excess humidity. In addition, an oversized unit will certainly cost more to buy and will likely add unnecessary dollars to your electricity bill. On the other hand, an undersized conditioner stands little chance of doing the job properly – and here again you will add unnecessarily to your energy bill, since the unit will stay operating most of the time. Thus, it is essential to understand – in a basic way – the capacity ratings expressed in BTU's.

Figure 3.12



An air conditioning unit's ability to cool is calculated in British Thermal Units – or BTU's. As a general rule of thumb, it will take about 18 BTU's to cool and dry one square foot of floor space in the average house or apartment. (Note: In metric units this is equivalent to 200 kJ/m^2.) Thus, an 18 000 BTU window air conditioner will cool some 1000 square feet. Expressed another way, the 18 000 BTU unit will cool a 20' x 25' living room, a 20' x 20' kitchen/dinette and a 15' x 12' dining room. Naturally there must be a fairly free flow of air between all interconnecting rooms. In addition, there will also be some cooling spill-over into hallways and stairwells.

A 12 000 BTU unit will cool about 650 square feet and a 9000 BTU unit will handle up to 500 square feet.

From Ontario Hydro, *Summer Cooling*, 1974.

★ Using the above information, calculate the required capacity to cool:

a) your bedroom
b) your home, excluding the basement

★ Do an energy analysis of your air conditioner.

1. Calculate the appliance's efficiency by converting the BTU/h to watts and compare this to the power input. (See the tables in section 7.)

$$\text{Efficiency} = \frac{\text{heat pumped (in watts)}}{\text{power input (in watts)}} \times 100\%$$

2. Explain the significance of your answer.

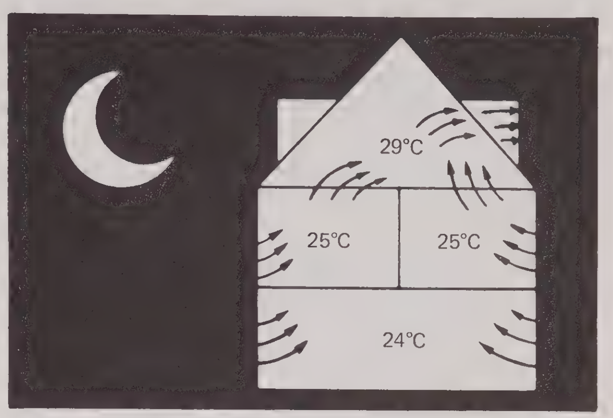
3. What are a few things to keep in mind to make effective and wise use of an air conditioner?

Note:
(i) Space heating is a growing area for the application of heat-pump technology. Find out what you can about the operation of heat pumps.

(ii) If the wattage of the unit is not shown on the air conditioner, use the method for determining power explained early in section 2. For example, if the unit works on 120 V and the current used is 10 A, then $P = V \times A$, that is,

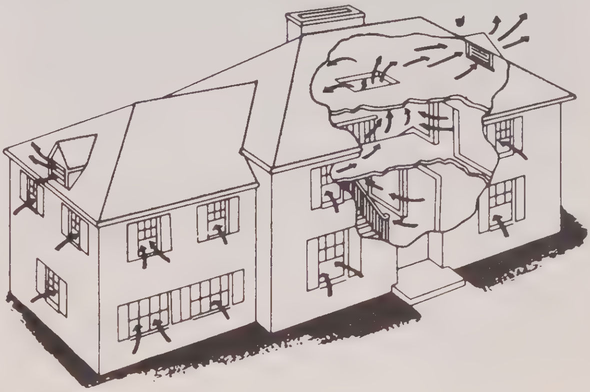
$$\begin{aligned} \text{power} &= \text{voltage} \times \text{current} \\ &= 120\ \text{V} \times 10\ \text{A} \\ &= 1200\ \text{W} \end{aligned}$$

Figure 3.13



Cooling With a Fan System

With a fan system, forced ventilation dissipates trapped heat. High capacity, axial fans exhaust the hot air and draw in cooler outdoor air to take its place, thus reducing indoor temperatures to a comfortable level. High-capacity fans may be installed in windows or, for best results, directly into the attic area.



Note: Figures 3.12 and 3.13 show the effect of an attic fan on both daytime and nighttime temperatures.

While some relief can be found by operating the fan during the noon-to-afternoon hours, the biggest difference can be appreciated after the sun has set. By extracting the attic heat and replacing it with cooler night air, the temperature has now dropped from 39°C to a moderate 29°C. In bedrooms and living rooms the temperature is a comfortable 25°C. Generally, a fan system costs less to install and operate than does an air conditioner. However, a fan system will not appreciably reduce humidity, nor will it remove dust or pollen from the air. An air conditioner may not either, since it is, in essence, merely a room cooler.

A Plan for Summer Cooling

★ Develop a plan for cooling your home in the summer that makes wise use of energy.

★ By means of a flow chart or energy chain, show how both fans and air conditioners make demands on our fossil fuels – just as heating does.

Here are some other ways to cool your home as recommended by Ontario Hydro, in *Summer Cooling:*

> *Bathroom Exhaust Fan*
> Turn on the bathroom exhaust fan or open the bathroom window after bathing. Be sure the bathroom door is closed. After several minutes, turn the fan off or close the window so that conditioned air from other rooms is not lost unnecessarily. Plastic shower curtains or glass doors are preferable to canvas or cloth, which absorb water and add to the moisture in your home.
>
> *Kitchen Vent Fan*
> When you cook on top of the range, a vent fan will exhaust heated air directly to the outside and relieve the burden on your cooling system
>
> *Attic Vent Fan*
> When it's 35°C outside, the temperature in your attic can be as high as 55°C. This layer of heat makes it more difficult to cool your living space. An attic fan – whether it's at a window, gable vent, or through the wall or roof – will put that hot, dead air out of the attic and reduce your attic temperature by as much as 20°C. Your air conditioner doesn't have to run as often when it isn't fighting a hot attic.
>
> *Window Fans*
> Except for the attic vent fan mentioned above, never run window fans open to the outside when the air conditioning is on. You can use fans to distribute cooled air from rooms with window units to rooms without them.
>
> *Insulation*
> Proper insulation is just as important in keeping your house cool in summer as it is in keeping it warm in winter. Make sure your insulation is up-to-date. [Refer to the unit on space heating.]
>
> *Keep Drapes Closed*
> Keep the hot summer sun outside by closing curtains during the day. This simple measure will avoid unnecessary heat gain from sunshine flooding through a picture window.

The activities in this section have shown you how the various appliances and devices in your home convert electrical energy to one form or another. In the next section, we will take a look at the costs involved.

4. Saving Energy Saves Money

Introduction

The first few activities in this section take a look at how electrical energy is sold to a customer using the residential rate structure. This is followed by a series of activities that make direct use of the hydro bills that come into a residence.

These, and earlier activities, show how our demand for energy varies with the time of day, week, month, and year. Since electricity must be produced "on demand", some activities dealing with this major problem are presented.

The section concludes with activities that allow the student to determine the cost of operating any device or set of devices for any given time.

The Residential Rate Structure – Electricity Costs Money

The Ontario Energy Board

A major concern of the consumer is the need for an adequate supply of electricity at a reasonable price. This price is based on how much it costs the power suppliers to generate and distribute electrical energy. When Ontario Hydro proposes a wholesale rate increase, it must make formal application under a full-dress public-review process before the Ontario Energy Board. This procedure was established by authority of the Ontario Energy Board Amendment Act of 1973 and applies to all proposed rate increases after January 1, 1975.

★ Have some member of the class find out the following, using the school's resource centre:

- Who is on this "Board"?

- When and how does it operate?

- What influences its decisions?

- Does it publish reports?

Rate Structure and Your Electric Bill

★ A strong argument for conserving electrical energy is to reduce the amount of the electric bill by reducing the electricity used. Just how are you charged for using electrical energy?

All power suppliers have rate schedules that show the price to customers for various types of service. The residential rates that became effective in 1974 in one Ontario city are shown in table 3.18.

You will note that, in general, the price per unit for energy decreases with greater usage.

★ Your group or class should discuss the following:

- What are the reasons for this kind of pricing policy?

- Does this rate structure encourage customers to use more energy?

- In the interests of conservation why would a different rate structure be more appropriate?

Table 3.18

1974 Residential Service Rate

Monthly Energy Charges		
1st	50 kW·h	@ 4.0¢ per kilowatt hour
next	200 kW·h	@ 1.8¢ per kilowatt hour
*next	750 kW·h	@ 1.05¢ per kilowatt hour
all additional kilowatt hours		@ 1.35¢ per kilowatt hour
minimum charge		$3.00 per month

The above rate includes charges for electricity used for house heating.

Table 3.19

1976 Residential Service Rate

Monthly Energy Charges		
1st	50 kW·h	@ 4.6¢ per kilowatt hour
next	200 kW·h	@ 2.3¢ per kilowatt hour
next	750 kW·h	@ 1.7¢ per kilowatt hour
all additional kilowatt hours		@ 1.8¢ per kilowatt hour
minimum charge		$3.50 per month

The above rate includes charges for electricity used for house heating and water heating.

Table 3.20

1976 Billing

Residential service bills generally cover two months of service and are calculated in the following way: –

Example: 2000 kW·h consumption in two months

100 kW·h	at	4.6¢	$ 4.60
400 kW·h	at	2.3¢	9.20
1500 kW·h	at	1.7¢	25.50
2000 kW·h			$39.30

Rate Structure and Incentives

★ 1. Both federal and provincial governments have requested that everyone try to conserve electricity. Do you feel that suppliers of electricity and electrical equipment are doing their part to promote conservation? Consider in your discussion the approach of the advertisements in newspapers, magazines, catalogues, and on radio and TV. Is it aimed towards energy conservation? Is it significant in your opinion?

2. Are the Canadian Standards Association and other regulatory bodies doing their part to conserve energy?

3. Both at an individual level and at a group or class level, develop a value continuum on each major issue that is brought into the discussion by first presenting each as a statement. (Techniques on how to develop a value continuum are outlined in the case study found in the early pages of the introductory unit.)

What Does It Cost Your Family *Now* for Electrical Energy?

★ Obtain the *current* rate schedule for the electricity your family uses. How does your current rate compare to the one in table 3.18?

★ An easy way to determine the *average cost* of 1 kW•h of energy is outlined in figure 3.14. Briefly, take a recent bill and deduct any charges that are *not* for energy; divide the cost by the number of kilowatt hours being charged for. In the example given in table 3.20, the average cost per kilowatt hour would be $39.30 ÷ 2000 kW•h = 1.97¢/kW•h.

★ All things being equal (and they never are), use the sample rates in tables 3.18 and 3.19 to predict what the residential service rates might be in 1978 and 1980. You can do this by increasing the charges for the next two years by the percentage that they increased during the previous two years.

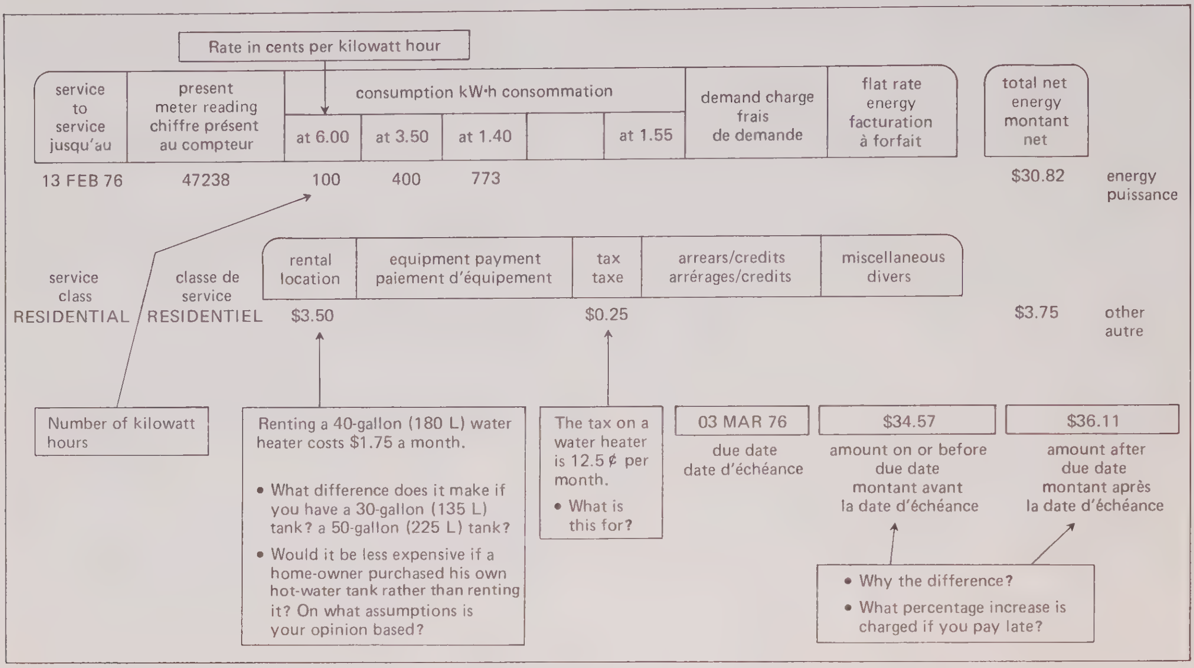
★ Table 3.20 is a sample billing for 1976. What would the cost have been in 1974 (see table 3.18)? Using your estimates for 1978 and 1980, what would the bill be then?

★ See if you can determine if your utility is considering any rate increases in the near future. Is it planning any changes in the overall rate structure?

The activities in the next section make use of the actual electrical bills sent to your home. Have your parents dig them out of the files for you. If your family has not been keeping the bill copies, start doing so. They will be of great interest over the next few years!

Figure 3.14

Using Your Hydro Bill



Rate in cents per kilowatt hour

service to service jusqu'au	present meter reading chiffre présent au compteur	consumption kW·h consommation at 6.00	at 3.50	at 1.40		at 1.55	demand charge frais de demande	flat rate energy facturation à forfait	total net energy montant net	
13 FEB 76	47238	100	400	773					$30.82	energy puissance

service class classe de service	rental location	equipment payment paiement d'équipement	tax taxe	arrears/credits arrérages/credits	miscellaneous divers		
RESIDENTIAL / RESIDENTIEL	$3.50		$0.25			$3.75	other autre

Number of kilowatt hours

Renting a 40-gallon (180 L) water heater costs $1.75 a month.

- What difference does it make if you have a 30-gallon (135 L) tank? a 50-gallon (225 L) tank?
- Would it be less expensive if a home-owner purchased his own hot-water tank rather than renting it? On what assumptions is your opinion based?

The tax on a water heater is 12.5 ¢ per month.

- What is this for?

03 MAR 76	$34.57	$36.11
due date date d'échéance	amount on or before due date montant avant la date d'échéance	amount after due date montant après la date d'échéance

- Why the difference?
- What percentage increase is charged if you pay late?

Obtain a copy of a hydro bill from your home and recalculate it. Determine the total amount of energy used over the billing time, the average cost per kilowatt hour, the average energy used per day, and the cost per day.

Calculation

100 kW·h at 6.00 ¢/kW·h =	$ 6.00
400 kW·h at 3.50 ¢/kW·h =	14.00
773 kW·h at 1.40 ¢/kW·h =	10.82
1273 kW·h	$30.82

for two months.

To Calculate the Average Cost of Energy

Energy used = 1273 kW·h
Cost = $30.82 (Do not add in rental!)

$\therefore$ Average cost per kilowatt hour

$$= \frac{3082\ ¢}{1273\ \text{kW·h}} = 2.42\ ¢/\text{kW·h}$$

Average Rate of Consumption

Assume 60/d.

$$E/t = \frac{1273\ \text{kW·h}}{60/\text{d}}$$

$$= 21.22\ \text{kW·h/d}$$

(or 51.45 ¢/d)

★ Refer to table 3.14 for your first activity with a hydro bill.

★ If bills for a year are available, they will give the cost and actual energy consumption on a monthly or bi-monthly basis. How much you can trust the individual values depends on how often the meter is actually read (find out). If you completed the earlier activity that dealt with billings and cost estimates, you can go back and revise your estimates so that the figures agree. It is surprising how close your rough calculations can be, if your original estimates were based on collected data and realistic thinking!

★ If you have hydro bills over a period of time such as a year or longer, plot a graph of the monthly consumption and account for the peaks and dips in the resulting curve (i.e., vacations away from home and residential-energy-requirement variations related to hours of daylight).

★ Using the actual energy consumed, and the costs from Hydro bills for one year, calculate the percentage accounted for by the "Top 10" (heavy user appliances). Refer to the activity you completed on measuring the energy used by appliances on p. 25.

★ If a member of your class or group has bills dating back two or three years, use them to plot a graph showing the average cost per kilowatt hour every time there was a billing. Plot on the same graph the average cost per kilowatt hour and the average energy being used over a period of time (say two months) against the date. Figure 3.15 uses the information provided in the electric bill in figure 3.14.

Extend the graph line on for a few years and draw conclusions.

Comparing Electricity With Oil and Gas

★ Take the total electrical energy used in one year and convert the total number of kilowatt hours to megajoules or gigajoules. Convert the energy into the equivalent number of gallons of #2 heating oil or cubic feet of gas. Consider the burning efficiency. The required tables may be found on p. 33.

Figure 3.15

Electrical Energy — Consumption and Cost Changes

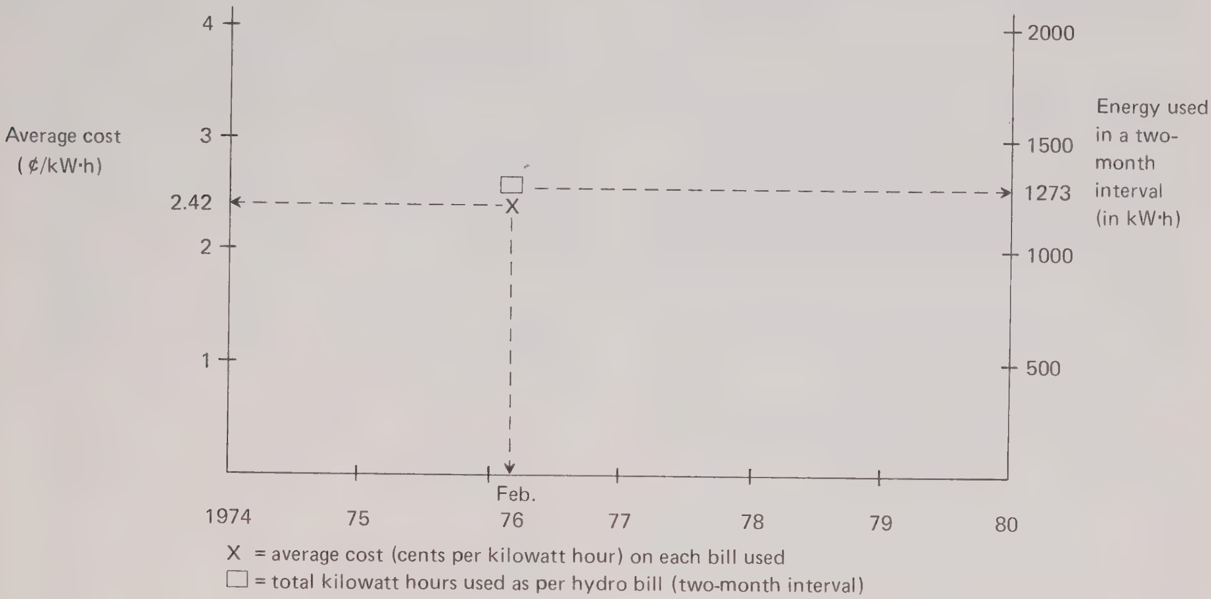


Figure 3.16 (a)

Daily summer peaking chart of a typical power plant in Ontario

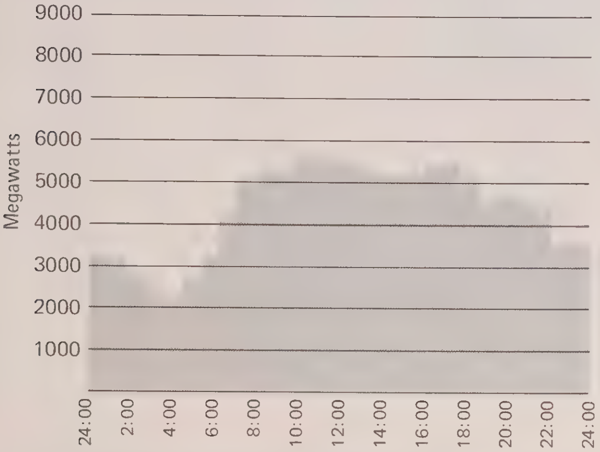
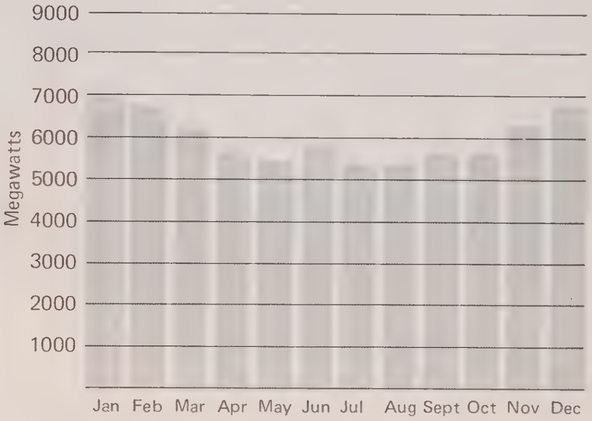


Figure 3.16 (b)

Maximum hour load each month of a typical power plant in Ontario



The Generation of Electricity — Can the Supply Meet the Demand?

Electrical energy is unique in that it must be used at the instant that it is generated. It cannot be stored. This characteristic creates many problems for power suppliers. They must be able to generate electrical energy to meet varying demands.

Because of the way we use electricity, our demands are not constant, but "peak" at certain times of the day, the month, or the year.

★ Consider the total output of a typical power plant in a generally cold climate like Ontario.

1. Discuss the shapes of the graphs shown in figures 3.16 (a) and 3.16 (b) and explain why the "peaks" occur at the times indicated.

2. What produces the lowest or "base" demand?

3. How does Ontario Hydro generate this base demand? How does it increase the power generated to accommodate peak demands?

4. Develop an appropriate graph like these for your home for a day, a week, and a year. Explain the base and peak demands in each graph. Use your electric bills to develop the yearly trends. For a daily graph, use the electric meter, making readings every two hours. Be as careful as you can to obtain precise readings.

Predicting Usage Patterns

★ 1. Through a discussion of current life styles, family activity patterns, etc., predict the hours of peak demand.

★ 2. If possible, use weekends or special assignment arrangements to have several teams or individuals read home meters hourly over a given period of time. Compile the results as a class. Compare these with your predictions in the previous activity.

Do Rate Schedules Determine Usage Patterns?

★ Obtain a rate schedule from your local electricity supplier for general service (commercial and industrial).

1. You will notice that a load or demand charge based on peak demand is assessed against customers in the general-rate category. How can this charge be justified? What options are open to these customers to minimize their demand charges?

2. Should a load or demand charge be used in the residential sector? Would increased rates at certain times of the day affect the way electricity is used? What are some ways you could shift the demands to different times of the day or week?

The last few activities in this section will show you how to convert your energy calculations (as you did earlier) into dollars and cents. Saving energy saves money! Can you present an argument that, in general, saving money is saving energy?

Learning to Estimate Appliance Running Costs

It is possible to estimate the cost of the energy used in running all of the devices or appliances you have looked at.

The average cost of electricity in Ontario for residential use varies from two to three cents (1977) per kilowatt hour, depending on where you live.

The approximate monthly cost of operating various appliances is determined by multiplying the kilowatt hour figure by the average cost of electricity in your community. For example, if the average cost where you live is 2.5¢/kW•h, the approximate monthly cost of electricity for a clothes dryer using 80 kW•h would be:
Cost = 80 kW•h x 2.5¢/kW•h = 200¢ = $2.00.

Calculating Costs

★ Select a few items from sections 2 and 3 on which you have done energy analyses and calculate their monthly and annual costs. Use your results from the activities in figure 3.15 for the average cost per kilowatt hour.

★ Select the ten largest electrical-energy-converting devices in your home and calculate the cost on an annual basis. Determine the percentage of the total electric cost these represent. Refer to earlier related calculations on p. 25.

★ Examine closely the *total flow* of electrical energy in your home, and the associated cost, either room-by-room or by category of device. Table 3.21 gives a typical result of such a survey, without organizing the items into either of the above groupings. Note the location of the hot-water heater!

Table 3.21

Residence Electrical Energy Use and Cost Audit

Electrical Device	Annual Energy Consumption (kW·h) *	Annual Cost of Energy Consumed **
Air conditioner	1 000	$ 25.00
Electric blanket	150	3.75
Can opener	0.3	.01
Clock	17	.43
Clothes dryer	1 200	30.00
Coffee maker	100	2.50
Dishwasher (with heater)	350	8.75
Fan (attic)	270	6.75
Fan (furnace)	480	12.00
Fluorescent light (3 fixtures)	260	6.50
Food freezer (16 cu. ft.)	1 200	30.00
Food mixer	10	.25
Food waste disposer	30	.75
Frying pan	240	6.00
Hair dryer	15	.38
Hot plate (2 burners)	100	2.50
Iron (hand)	150	3.75
Light bulbs	1 870	46.75
Radio (solid state)	20	.50
Radio phonograph (solid state)	40	1.00
Range	1 550	38.75
Refrigerator (frost-free, 12 cu. ft.)	750	18.75
Sewing machine	10	.25
Shaver	0.6	.02
Television (black and white)	400	10.00
Television (colour)	540	13.50
Toaster	50	1.25
Vacuum cleaner	45	1.13
Washer (automatic)	100	2.50
Sub-total	10 947.9 kW·h	$273.72
Hot water heater	6 000 kW·h	150.00
Total	16 947.9 kW·h	$423.72

*Average
**Cost of electricity at 2.5¢ per kilowatt hour

★ Use your flow chart developed in figure 3.7 or rearrange the entries in table 3.21 into groups of devices that are making similar conversions (heat, light, motion, etc.). Determine the cost each group contributes to the total cost.

★ Suggest the most important areas and devices that should be concentrated on for realistic energy-conservation practices as well as for saving money.

It may be true that as the cost goes up, people will naturally attempt to conserve energy. The activities in this section have shown you this "expensive" side of energy. However, the expense is related to the cost of producing and distributing the energy. This and the control of energy use in our society are examined briefly in the next section.

5. Problems With Meeting the Demand

Introduction

The generation and production of electrical energy is normally far removed from the eyes of the user, who is just not aware of the source of this invisible energy.

This section deals briefly with the problems of generating and transmitting electricity. We must pay for our demands by depleting our natural resources and by modifying our environment.

The concluding activities show that all sectors of our society make great demands on electricity and that control of these interrelated components of the total system is extremely difficult to achieve.

Ontario Hydro Looks into the Future

TORONTO (CP) – Ontario Hydro will need at least half of Canada's total uranium requirements by the year 2000 for production of electricity, the royal commission on electric power planning was told Thursday.

Hydro representatives at the commission's 40th public information hearing gave details on the availability and forecast supply of fuels in Ontario.

John Matthew, director of fuels, said economic, environmental and security of supply factors will bring about a trend toward the use of uranium rather than coal over the next 20 years.

He said Hydro predicts that uranium eventually will be more easily available than coal.

Bringing coal from Western Canada would involve a "tremendous economic penalty," he said, adding he could not be "100% sure" of future coal supplies from the United States.

Stuart Hunter, fuel resources engineer, said in an interview later that the bulk of available uranium for the next 25 years is in Ontario.

"We'll probably have to look elsewhere in Canada after the year 2000," he said.

From the *Ottawa Citizen*, June 4, 1976.

★ 1. Explain briefly, or draw a conclusion from, each sentence of the above press release made on June 4, 1976.

★ 2. What types of electrical generation are not referred to in the article?

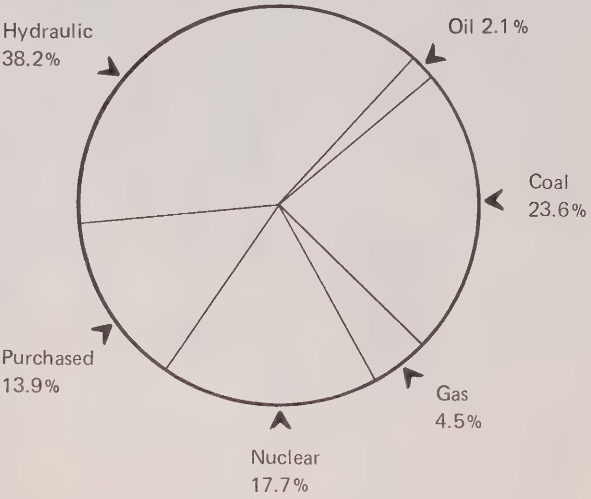
The next few activities will take a brief look at how electricity is generated in Ontario, and how the methods and their by-products affect the environment.

Generating Electricity

In 1976, Ontario Hydro produced 30.1% of its electrical power from oil, gas, and coal, 17.7% from nuclear energy in the form of the CANDU reactor, and 38.2% from water power. Electricity generated by falling water is called "hydro-electricity"; that produced by fossil fuels or by nuclear reactors is referred to as "thermal electricity".

Figure 3.17

Ontario Electric Power Generation 1976*

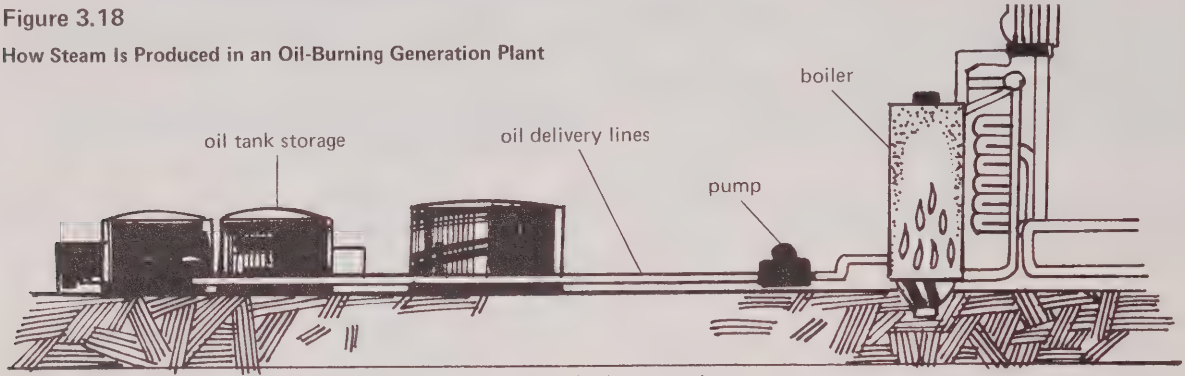


* 9 Months Actual, 3 Months Forecast

Using the Steam Turbine and Generator (Figures 3.18 to 3.23)

Figure 3.18

How Steam Is Produced in an Oil-Burning Generation Plant



Note: Natural gas is also used by connecting a gas line to a gas boiler to produce steam.

Figure 3.19

How Steam Is Produced in a Nuclear Generating Station

A reactor building
B steam pipes to turbines
C steam drums
D heat exchangers
E heavy water pumps
F reactor
G fuelling machines
H end shield
I dump port
J heavy water dump tank

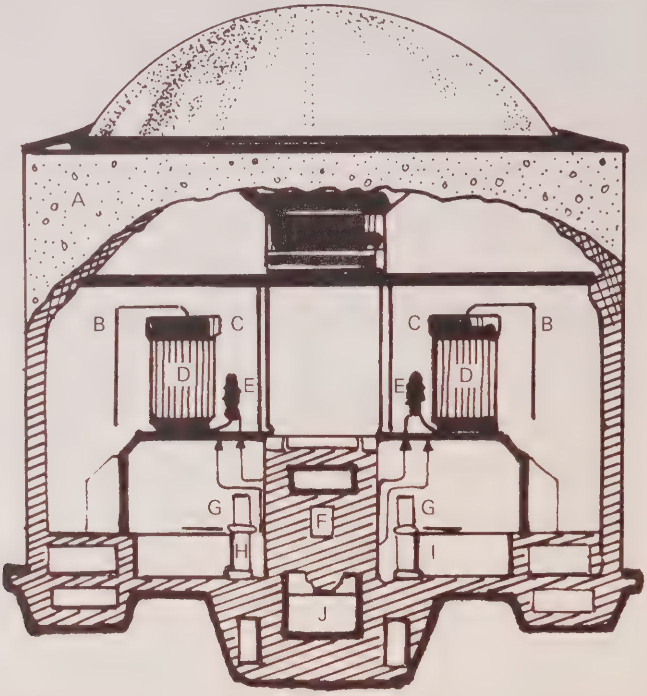


Figure 3.20

How Steam Is Produced in a Coal-Burning Generating Plant

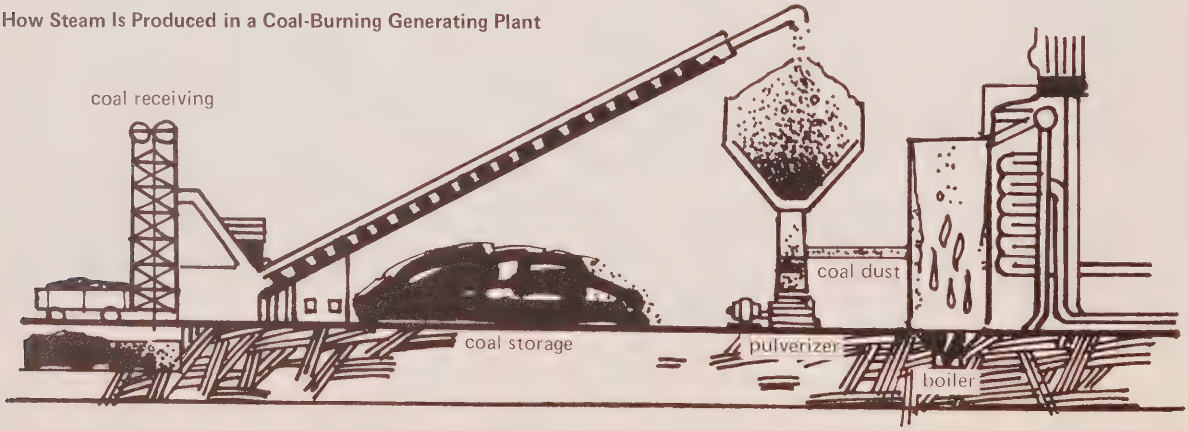
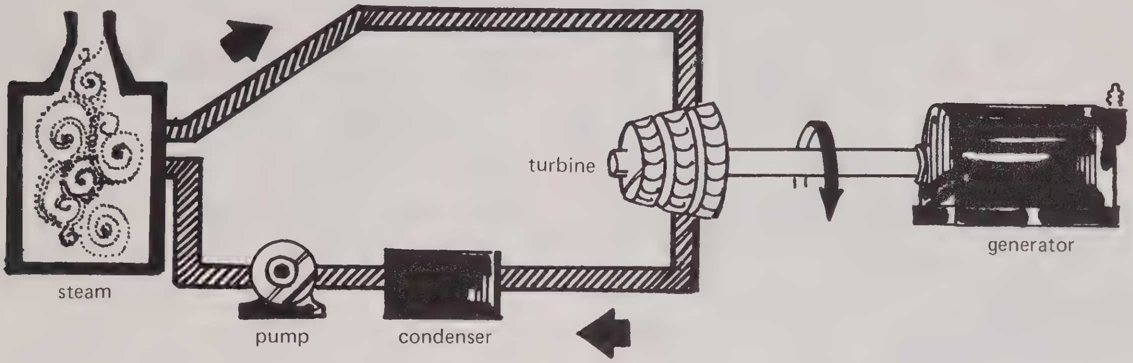


Figure 3.21

Principle of a Steam-Powered Generator



In 1976, about 38% of the power produced by Ontario Hydro was hydro-electric, or hydraulic. In 1975, it was 42%!

★ Explain how Ontario Hydro makes use of the water cycle (see figure 3.23). Relate this concept to the Ontario watersheds by referring to the map on p. 4 and by using these questions to organize your thoughts: To what extent have available water sources already been dammed and used? How does climate affect electrical generation? What appears to be happening to the Canadian climate in the long-range view? What are the implications of this for the generation of electricity? What other demands do we place on the portion of the water cycle operating in Ontario? Why is Ontario Hydro planning virtually no expansion of this type of generation?

Electricity is generated by other means than dammed water. In Ontario, it is these other processes that are on the increase.

★ Using figures 3.18 to 3.22, outline briefly the major steps or energy conversions required to produce electricity. For each method of production, state two problems associated with increasing this method of generation.

Figure 3.22

Using the Water Turbine and Generator

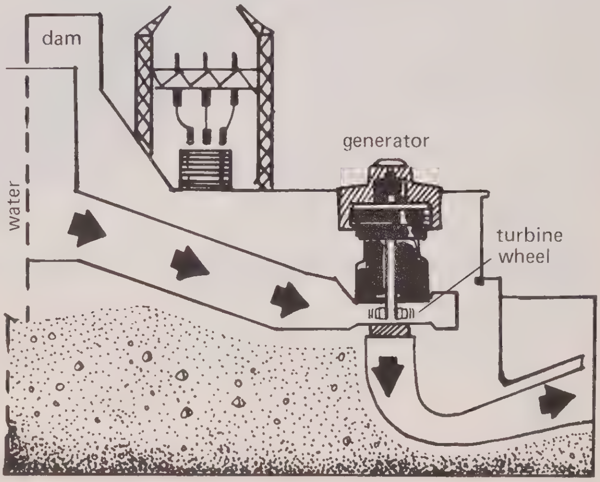


Figure 3.23

The Water Cycle

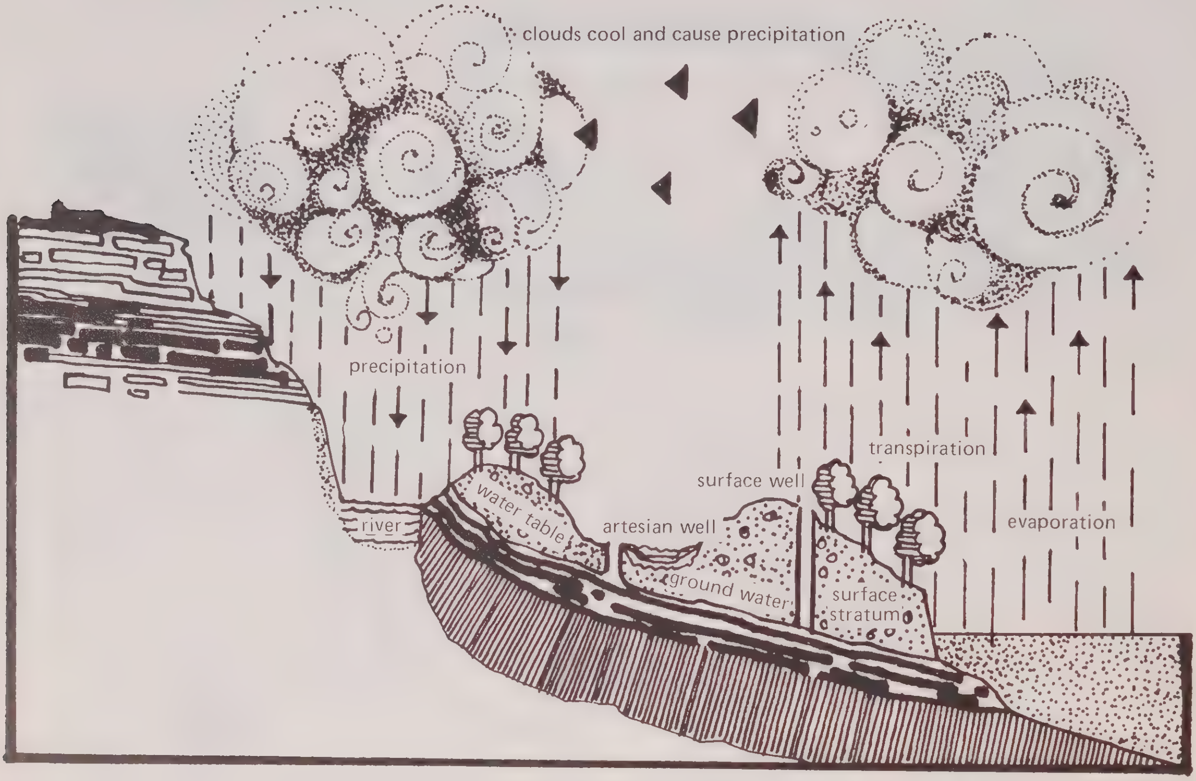


Table 3.22

Environmental Effects of Electric Power Generation

Energy Source	Effect on land	Effects on water	Effects on air	Biological effects	Supply
Coal	Disturbed land. Large amounts of solid waste. Mine tailings	Acid mine drainage. Increased water temperature	Sulfur oxides. Nitrogen oxides. Particulates	Respiratory problems from air pollutants	Large reserves
Oil	Wastes in the form of brine. Pipe line construction	Increased water temperature	Nitrogen oxides. Carbon monoxide. Hydrocarbons	Respiratory problems from air pollutants	Limited domestic reserves
Gas	Pipe line construction	Increased water temperature	Some oxides of nitrogen	None detectable	Large domestic reserves
Uranium	Disposal of radioactive waste. Mine tailings.	Increased water temperature. Some radioactive liquids	Some release of radioactive gases	Non-defectable in normal operation	Moderately large reserves

Source: John J. McDermott et al, "Environmental Effects of Electrical Power Generation — Nuclear and Fossil" (Philadelphia, Penn.: Pennsylvania Department of Education, 1973), p. 61.

The Environmental Effects of Generating Electricity

★ Each type of electrical generation described in figure 3.24 produces "waste heat". What percentage of the electrical output is the heat energy produced in each case? What is your conclusion? What is thermal pollution? How could this heat be put to use? Is it being used in any Ontario power plants?

★ Using the tables in section 7, convert the gas and oil input quantities to megawatts, then calculate the efficiency of the production of electricity using these two methods.

★ What are some of the problems concerning availability and costs associated with the primary fuels as related to Ontario Hydro? In what direction do you think production expansion will take place to meet our needs?

★ All production methods produce steam to drive turbines that in turn drive generators. Develop this idea in greater detail using diagrams to assist your presentation.

★ Discuss the problems associated with the various other "wastes" (the "by-products" of electrical generation) and their effects on us.

★ If we need more electricity, how are we going to generate it? Hold a group or class discussion based on the information in table 3.2.2. During the discussion, consider the following questions:

1. Do we wish to maintain our standard of living, or do we wish to give up some or all of the conveniences and products we now enjoy?

2. Do we wish to continue as we are, ignoring the environmental cost? If we do, are we willing to pay the ultimate price?

3. How can we produce the electricity we need with the least expenditure of our mineral resources and with the least cost to our environment? (See table 3.22.)

4. What are the alternatives to the nuclear generation of power?

5. Are the advantages of nuclear generation (or any other method of generation) worth the price?

Transporting the Energy to You

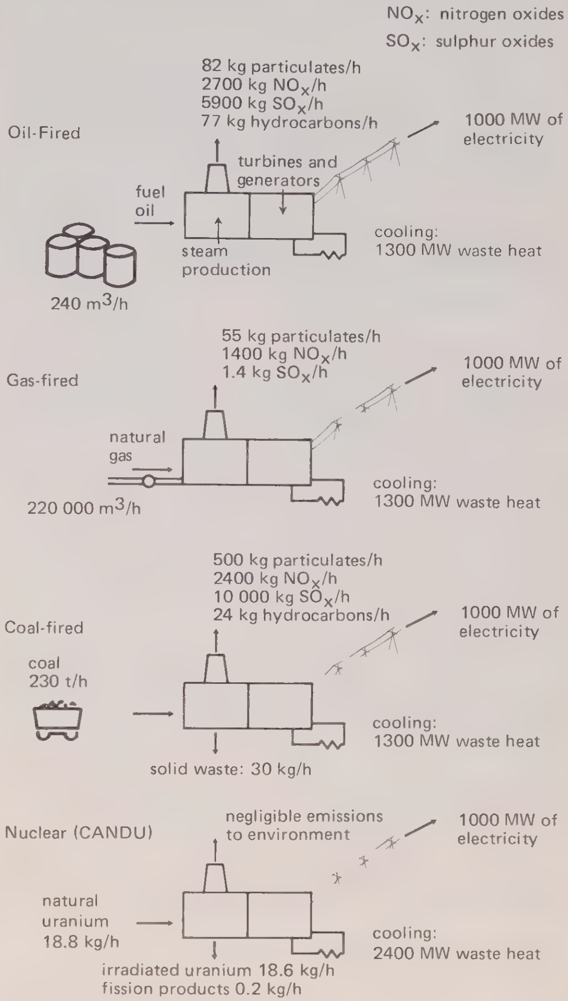
Even if we can generate the required electricity, there may be difficulties in transmitting it to you!

> *Hydro Forecasting Hard Years Ahead*
>
> BARRIE (CP) – The next three or four years will be critical for Ontario Hydro's power-transmission capacity, Hydro officials said Wednesday at a public hearing of the royal commission on electric power planning.
>
> H. P. Smith, systems planning director, said Hydro's transmission capacity will be more strained than its generating capacity until the early 1980s.
>
> Paul Dandeno, analytic planning manager, said transmission facilities are being used with a margin for emergencies that would have been considered unacceptable a few years ago.
>
> From the *Ottawa Citizen.*

Figure 3.24

Fuel Imputs and Emissions from 1 000 MW Conventional Electric Power Plants

Source: "The Energy Crisis", AAAS Symposium, Philadelphia, December 1971 (converted to metric and adapted)



★ Do some research on how electricity is transmitted and distributed. Your work could cover:

1. transformers – (principle of operation, step-up and step-down transformers)

2. transmission lines – (structure, voltages)

3. distribution lines – (primary voltage, secondary voltage, overhead versus underground)

4. substations – (transmission versus distribution)

5. energy losses in transmission and distribution lines

★ State the nature of the general problem faced by Ontario Hydro in attempting to solve its transmission needs.

The majority of the activities so far have involved you with conserving the use of electricity in the home and perhaps the school. This sector of our society is only one component of a much larger system. The last few activities in this section will attempt to show you that you can have an effect on promoting energy conservation in the non-residential areas of the system.

Use of Electricity in the Industrial, Commercial, and Government Sectors – Does It Involve You?

a) Industry

★ Believe it or not, you can save electrical energy by reducing your demands on those materials that use large quantities of electricity in their production. The aluminum industry is one example of the great consumers of electricity. Much energy is needed to separate the aluminum from the raw ore.

1. Assume that we heavily tax large users of electricity and that the costs are passed along to the consumer. Work out a table of price versus percentage tax increase for some typical aluminum consumer products. At what point will the tax clearly affect the sales and use of *each* product?

2. Assume instead that the government orders the industry to discontinue the manufacture of non-essential aluminum products. What products would you put in this classification? How would this action affect the way you live?

3. Try to find out how much electrical energy is required to produce 1 kg of aluminum, or perhaps the aluminum used to make one pop can.

4. Explain how just avoiding the use of aluminum products, where possible, will save energy. What are "boycotts"? Does Ontario have a policy on "non-returnable" containers?

★ **b) Commerce**

1. By referring to table 3.23, compare the actual changes seen over a two-year period in the general rate charges with the type of structure proposed in the first two newspaper articles on the next page.

2. Use the rates given to work out the 1974 and 1976 charges that a store would have if it used 2 000 000 kW•h. (No load charges).

3. List five reasons why stores and offices today use almost twice as much electricity as they did ten years ago.

4. How can you (the public) have an effect on the energy consumption in commercial establishments?

Table 3.23

1974 General Rate

Monthly Energy Charges		
1st	50 kW·h	@ 6.0 ¢ per kilowatt hour
2nd	200 kW·h	@ 3.3 ¢ per kilowatt hour
3rd	9 750 kW·h	@ 1.93¢ per kilowatt hour
4th	2 140 000 kW·h	@ 0.78¢ per kilowatt hour
all additional kW·h		@ 0.42¢ per kilowatt hour
load or demand charge over 50 kW		@ $2.80 per kilowatt
large user over 5000 kW		
total demand		@ $4.35 per kilowatt
all energy		@ 0.42¢ per kilowatt
minimum charge for		
service under 50 kW·h		@ $3.50 per month
service over 50 kW·h		@ 25¢ per kilowatt hour
for all kilowatts based on the maximum demand established during the previous eleven months or the contracted amount whichever is the greater.		

1976 General Rate

Monthly Energy Charges		
1st	50 kW.h	@ 6.0¢ per kilowatt hour
2nd	200 kW·h	@ 3.6¢ per kilowatt hour
3rd	9 750 kW·h	@ 2.35¢ per kilowatt hour
4th	1 540 000 kW·h	@ 1.2¢ per kilowatt hour
all additional kW·h		@ 0.7¢ per kilowatt hour
load or demand charge over 50 kW		@ $2.80 per kilowatt
large user over 5000 kW		
total demand		@ $4.35 per kilowatt
all energy		@ 0.7¢ per kilowatt
minimum charge for		
service under 50 kW·h		@ $3.50 per month
service over 50 kW·h		@ 25¢ per kilowatt hour
for all kilowatts based on the maximum demand established during the previous eleven months or the contracted amount whichever is the greater.		

c) Government

Read the following newspaper articles.

> *Building Owners Warned: Turn Off Lights or We'll Do It: Timbrell*
>
> TORONTO (CP) – Owners and managers of commercial buildings in Ontario who continue to waste electricity might face direct government action, Energy Minister Dennis Timbrell said Tuesday.
>
> In a speech to the Building Owners and Managers Association, Mr. Timbrell said he is tired of having to reply to letters complaining of lighting in commercial office towers at night.
>
> "Every night, when I look out my office window, I see the major bank towers lit up on all floors.
>
> "The tallest of them is only half rented but all 70 stories are burning brightly," he said.
>
> If lighting is considered a form of advertising, it is "a very irresponsible way to promote office space given our need to conserve energy," he said.
>
> He rejected arguments that lights last longer if they are not turned on and off and are needed for heating.
>
> Mr. Timbrell said consumption of electricity by the commercial sector is rising 11% annually – "a far faster rate than in the residential or industrial sectors."
>
> He told building owners and managers attending a one-day energy conservation seminar that if they took no action soon, "you may be treated to quite a surprise."
>
> "It isn't just a question of public resentment. It could also be a matter of public policy."
>
> He said an overhaul of electricity pricing will discourage unnecessary use of power by commercial buildings at peak periods.
>
> "If things get serious enough, allocation of power may be a possibility, he said."
>
> From the *Ottawa Citizen,* January 19, 1977.

> *Ontario Can't Squeeze Those Federal Bulbs*
>
> Ontario energy officials, gazing upon brightly-lit federal office buildings, are currently limited to blowing figurative fuses.
>
> But they're planning for a future which will give them more constructive approaches to controlling uses of power.
>
> "There's nothing we can do about the federal government leaving the lights on," said Ted Ball, executive assistant to Energy Minister Dennis Timbrell.
>
> But Ontario has a gas allocation bill at present which permits gas to be distributed according to stated priorities in the event of a shortage, and if electricity becomes a scare commodity it could well be subject to similar legislation, he said.
>
> That would follow a period in which electricity is priced to discourage unwise use – a stage which is being planned right now.
>
> Mr. Timbrell told Toronto building owners and managers Tuesday they would have to join the fight against energy waste or face government action to enforce conservation.
>
> Mr. Ball said the same message had gone to Ontario government departments.
>
> From the *Ottawa Citizen,* January 19, 1977.

★ 1. What are the arguments for and against leaving lights on?

2. What authority does a provincial government have over energy use by industrial, commercial, and Federal-Government users as well as over its own use?

3. How did the Federal Government and some industries reply to these "charges"? Find any relevant articles that appeared in the *Globe and Mail* in the week following the appearance of the above two articles.

Our Society Demands Energy

Approximately one-fourth of all energy is used in producing electric energy.

> *Running Out –*
> *Oil deficit predicted*
>
> TORONTO (CP) – The royal commission on electric-power planning was told Monday that Canadian oil supplies will not be sufficient to meet domestic demands in this decade and that the deficit will increase.
>
> The Ontario energy ministry submitted a brief based on reports of the National Energy Board and on a federal government report on energy strategy.
>
> The commission was set up last year by the province to look into electric-power-system planning for the period 1983 to 1993 and beyond.
>
> The brief said production of natural gas is insufficient to supply both domestic and export requirements and that production from established areas will not satisfy domestic demands by the late 1980s.
>
> Coal from Western Canada will be considerably more expensive than current supplies from the United States, and production from current uranium reserves will not be adequate to meet Canadian and export needs by the late 1980s and domestic needs alone by the early 1990s, the brief said.
>
> From the *Ottawa Citizen,* September 9, 1976.

★ 1. Who is/was on the "royal commission" and what is/was its role?

2. Both the National Energy Board and the Federal Government have "reports" on energy strategy. (See if you can get a copy.)

3. What four fuels used for the production of electrical energy are referred to above and what is the basic problem with each?

Energy policy asked – Hydro hike 'disaster'

CAMBRIDGE, Ont. (CP) – Executive Jack Shurie said today the recent Ontario Hydro proposal for an increase of more than 33% in bulk power rates for next year is "part of a disastrous lack of over-all energy policy in Canada."

Mr. Shurie, vice-chairman of the Association of Major Power Consumers in Ontario, told the Kiwanis Club that Canada seems "to be getting further and further away from an intelligent over-all national energy policy."

"Traditional attitudes no longer hold true . . . and we are trying to persuade Ontario Hydro that its attitudes, formed in the good old days of a seemingly limitless supply of low-cost electric power, will not work either."

'Unrealistic'
Mr. Shurie, vice-president of The Exolon Co. of Thorold, Ont., said the proposed rates are unrealistic, and referred to one large pulp and paper company, not identified.

This company's annual energy bill was about $6.5 million, a sum that would rise to $10.5 million if the bulk power rate is approved.

"This, in turn, represents an increased cost of $5 per one-ton roll of newsprint and $2 on each ton of pulp."

From the Ottawa Citizen, July 27, 1976.

★ 1. What is a "bulk" power rate?

★ 2. Who should be and who is involved in formulating an overall energy policy for Canada?

★ 3. Who might be represented in the Association of Major Power Consumers? Find out who is represented.

★ 4. Why do you think Mr. Shurie made such a statement about Canada getting farther and farther away from an intelligent overall national energy policy?

★ 5. What "traditional attitudes" no longer hold true?

★ 6. What attitudes of Ontario Hydro "will not work either"?

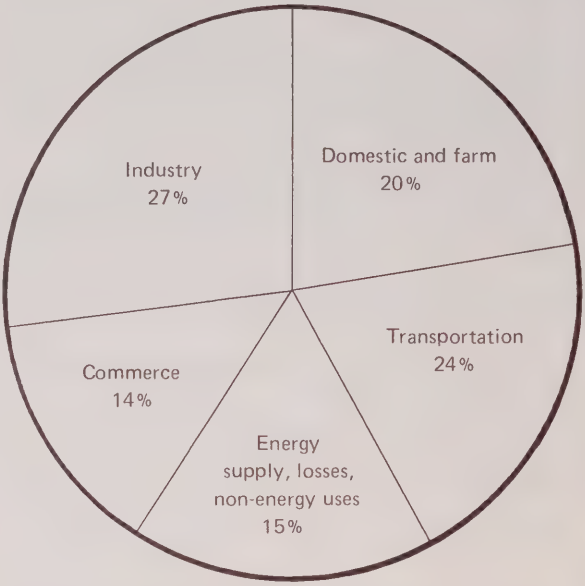
★ 7. To whom are increased costs usually passed on?

★ After reading the two articles above and answering the questions, develop a few examples that will show:

1. how increased costs of electrical energy production will affect you and your family in *all five sections* of figure 3.25;

2. how decisions you and your family make can reduce the demand in all five sections of the graph. Since energy flows are interrelated, energy-conservation measures adopted at home (or school) have an indirect effect in other areas.

Figure 3.25



Classification of electric energy users and approximate per cent of consumption in 1975.

As you can see, the generation, transmission, and use of electrical energy in our society presents many problems and few solutions. It is one thing to be aware of this; it is quite another to do something about it!

The many activities you have worked through have shown you how your day-to-day decisions can be modified if you wish to become a "conserver". Other things you can do are outlined in the next section.

6. Action Plans

Introduction

The fifteen activities in this section offer some ideas of what concerned students can do after working through the activities in the other sections. The most important and hoped-for result would be a change in attitude – a real concern for the rate at which we are converting our natural resources into electrical energy.

It would be nice to think that, as a result of this study, decisions might be made, in a fair number of homes across the province, to implement a more cautious and a wiser use of electricity than has existed.

Things You Can Do

In Your Own Home

★ 1. From the electrical-energy analysis you have produced for your home, devise a realistic way to cut down your conversion by 10%. Your decisions should be relatively easy to carry out or they will not be done! Discuss the ideas with your family and ACT upon your decisions.

In Your Class

★ 2. With your group or class, develop a concise argument (one page maximum!) on whether you, your family, and others in Ontario should or should not take steps to conserve electrical energy along with other forms of energy. Refine the list of "reasons" you started in section 1 to explain why an energy consumption growth of 7% cannot realistically continue.

★ 3. If your conclusion is "yes, we should conserve electricity", develop a list of the most *effective* and *realistic* ways of doing this in your home, school, *and* community (one page maximum for each!).

★ 4. Make creative presentations, such as collages, wall murals, mobiles, and songs, related to the energy-crisis theme.

★ 5. Find and use information in recent newspapers and magazine articles that relate to the energy crisis and conduct a discussion or debate or design a role-playing activity based on the topic "Energy Crisis: Fact or Fiction?".

★ 6. Compose short stories or plays around possible results of energy failure or of the energy-conservation effort.

In Your School

★ 7. Prepare several energy-conservation posters and place them in strategic locations throughout your school. Call attention to the need for shutting off unnecessary lights, closing doors and windows, lowering thermostats, or buying the proper appliance for a particular job.

★ 8. Arrange to work with school administrators to find and develop ways to save energy within the school. Can it be cut by 10%?

★ 9. Write articles and poems dealing with energy for publication in the school newspaper.

Positive Action in the Home Neighbourhood

★ 10. Develop a list of suggestions to reduce electrical-energy consumption in the home. With your group or class, refine this list and produce copies to distribute to homes in your neighbourhood. Refer to the first three activities in this section. Include the reasons why we should conserve.

★ 11. Survey the businesses in your neighbourhood and find out what conservation measures are being used. Have they turned down their thermostats and hot-water heaters? Have they turned off unused lights and stopped using outdoor lighting displays, etc.? Leave with them the ideas you developed in the second and third activities above.

★ 12. Obtain permission from school officials to approach a local radio or television station to arrange for students to conduct a talk show featuring ideas on how local citizens could conserve energy.

★ 13. Develop a model of the dials on the electric meter and visit homes in your community showing the residents how to read the meter. Develop an energy record chart to go with the presentation and leave copies with the home owners along with your recommendations on how to conserve electrical energy.

Energy Conservation and Personal Attitudes and Values

★ 14. This electrical-energy analysis has given you a good indication of just how and why you use electricity – a picture of you and your community's "electrical life style". What attitudes and values are associated with each of the main areas of use? Discuss these with your group or class. What basic changes will have to take place in these attitudes and values if we are to move towards a conserver society rather than a consuming one?

★ 15. Try to arrange a discussion with a representative from your local electricity supplier or Ontario Hydro concerning a conserver-society attitude in relation to electrical energy. Perhaps media coverage (i.e., newspaper, radio, TV, etc.) of such a discussion or a "bear pit" session could be arranged to focus public attention on the issues in a conserver society.

In each of these activities you are going to expend energy in order to attempt to save energy. Invest wisely. Let's remember that electricity is only one of many energy commodities: we will need the thoughts and ideas we have for its use to apply to conservation of other forms of energy.

7. Support Materials

Tables of Data and Units

1. Common Metric Prefixes

The following table shows some common metric prefixes which are used to form multiples and sub-multiples of metric units.

Figure 3.26

Table of Common Metric Prefixes

Prefix	Symbol	Value	Meaning	Example
mega	**M**	1 000 000	million	***Mg** for megagram
kilo	**k**	1 000	thousand	**km** for kilometre
† hecto	**h**	100	hundred	**ha** for hectare
† deca	**da**	10	ten	**dal** for decalitre
† deci	**d**	0.1	one tenth of	**dm** for decimetre
† centi	**c**	0.01	one hundredth of	**cm** for centimetre
milli	**m**	0.001	one thousandth of	**ml** for millilitre

* 1 Mg (megagram) = 1 000 000 g = 1000 kg = 1 t (tonne or metric ton).

† As a rule, these prefixes are not used except in hectare, decimetre, and centimetre.

Source: Ontario Ministry of Education, *Writing SI Metric* (Don Mills, Ontario.: Metric Promotions Toronto, 1976), p. 4.

The most common prefixes are

kilo
centi → **metre**
milli

kilo
→ **litre**
milli

kilo
→ **gram**
milli

A simple aspect of the metric system is the use of a common set of prefixes with the root words to form larger and smaller units. Kilo (k) means "1000 times" and so kilometre means 1000 metres, kilolitre means 1000 litres, kilogram means 1000 grams, kilowatt means 1000 watts, etc. We may not know what a pascal is but we can tell that one kilopascal equals 1000 pascals.

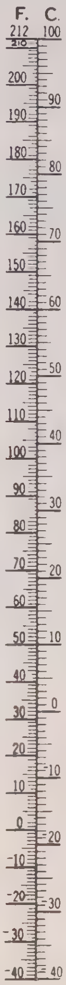
Thus, we can combine any prefixes with any root words to form the various units.

From Ontario Ministry of Education, *Writing SI Metric* (Toronto: Metric Promotions, 1976), p. 4.

2. Range of Temperatures

Figure 3.27

Range of Temperatures

500° C	Wood alcohol burns	430°C	 F. C. 212 100 200 90 190 180 80 170 160 70 150 140 60 130 120 50 110 40 100 90 30 80 70 20 60 50 10 40 0 30 20 10 10 0 20 -10 -20 30 -30 -40 40
	Zinc melts	419°C	
400° C	Mercury boils	357°C	
	Lead melts	327°C	
300° C	Wood burns	250°C	
	Hot oven	210°C	
200° C	Paper burns	185°C	
	Medium oven	180°C	
	Low oven	150°C	
	Hottest on the moon	117°C	
100° C	Water boils	100°C	
	Alcohol boils	78°C	
	Body temperature of song birds	50°C	
	Human body temperature	37°C	
0° C	Water freezes	0°C	
	Mercury freezes	–39°C	
	Coldest weather (Antarctica, 1960 08 24)	–88°C	
-100° C	Alcohol freezes	–118°C	
	Coldest on the moon	–163°C	
-200° C	Oxygen freezes	–218°C	
	Absolute zero	–273.15°C	

From: Council of Ministers of Education, Canada, *The Metric Guide* (Toronto: Canadian Standards Association, 1975), section 182.

3. Energy

1 W•s (watt•second) = 1 J (joule)

1 kW•s = 1000 J = 1 kJ (kilojoule)

1 kW•h (kilowatt hour) = 3 600 000 J = 3.6 MJ (megajoules)

1000 BTU = 0.293 kW•h = 1055 kJ = 1.055 MJ

1 GJ = 1 000 000 000 J = 1 000 MJ

4. Power

1 W (watt) = 1 J/s (joule per second)

1 kW (kilowatt) = 1000 J/s

1 MW (megawatt) = 1 000 000 J/s

1 GW (gigawatt) = 1 000 000 000 J/s

1 HP (horsepower) = 746 W = 0.746 kW

1 BTU/h (British thermal unit per hour) = 0.293 W

1000 BTU/h = 0.293 kW

5. Special Conversion Chart

1 imperial gallon #2 heating oil = 168 000 BTU's = 177 MJ, assuming a 100% conversion efficiency.

1 imperial gallon #2 heating oil = 109 200 BTU's = 115 MJ, assuming a 65% conversion efficiency (average oil furnace).

1 cubic foot of natural gas = 1050 BTU's = 1.108 MJ, assuming a 100% efficiency.

1 cubic foot of natural gas = 1050 BTU's = 0.781 MJ, assuming a 70% conversion efficiency (average gas furnace).

1 kW•h of electricity = 3412 BTU's = 3.6 MJ, assuming a 100% conversion efficiency.

1 kW•h of electricity = 3412 BTU's = 1.224 MJ, assuming a 34% conversion efficiency (average percentage efficiency of electrical power production and transmission in Ontario).

6. Population Estimates 1960–2000 (Five-Year Intervals)

Table 3.24

Population Estimates

Year	Canada (x 1000)	Ontario (x 1000)	Toronto	Your Municipality	The City Nearest to You
1950	14 000	4 598 (1)	1 117 470*		
1955	16 000	5 405	1 358 028		
1960	18 238	6 236	1 618 787		
1965	19 000	6 961	1 881 691		
1970	21 568	7 703	2 086 017		
1975	23 086	8 331 (2)	2 887 000†		
1980	25 311	9 027	3 127 000		
1985	27 810	9 747	3 340 000		
1990	30 177	10 433	3 530 000		
1995	32 347	11 055	3 699 000		
2000	34 611	11 629	3 852 000		

Sources:

i) Canada population estimates from D. Paul et al, *Energy and the Conservation Laws* (Toronto: Holt, Rinehart and Winston, 1974), p. 72.

ii) Ontario population estimates from:

(1) (1950-1970) Statistics Canada, Catalogue #91–201 (chart), *Estimated Populations of Canada and the Provinces,* 1972–2001 (Ottawa: Statistics Canada, 1976);

(2) (1975-2000) Statistics Canada, Catalogue #91–514, *Population Projections for Canada and the Provinces* (1972–2001) (Ottawa: Statistics Canada, 1974).

iii) Toronto population estimates from:

*(1950–1970) Statistics Canada, Catalogue #92–702, *Population – Historical* (Ottawa: Statistics Canada, 1971);

†(1975–2000) Publication B–75–10, discussion paper prepared by the Demographic Research Group of the Office of the Ministry of State for Urban Affairs (Ottawa: Ministry of State for Urban Affairs, 1976).

7. Energy "Slave" Calculation

Assuming a strong man can work at the rate of 100 W for 8 h at a stretch, then,

1 slave power = 100 W
= 2.88×10^6 J/d (8 h only)
= 1.1 GJ/a (8 h days for 365 d!)

You would need three such slaves in shifts of 8 h each to keep up the rate continuously. Thus,

1 slave working continuously = 100 W
= 8.64×10^6 J/d
= 3.15 GJ/a

In 1974, *each* Canadian, on the average, used approximately 400 GJ during the year. This represents *127 slaves working continuously* or about 381 slaves working in 8 h shifts!

Glossary of Terms

AECL (Atomic Energy of Canada Limited). Crown Corporation involved in the research, development, and demonstration of nuclear energy in Canada.

Alternating current. Current that reverses its direction of flow at regularly recurring intervals of time.

Ampere (A). Unit of current or rate of flow of electric energy.

Average load. Average demand for electrical power. Usually given in terms of megawatts (MW) in industry and kW in residences.

Base load. Generation capacity that is always required, independent of peaking, etc. The base load is generated mainly by hydraulic and nuclear sources.

Brown out. A failure of the electrical grid system to maintain voltage during a period of peak usage.

Bulk power costs. Total annual cost of operating Hydro's bulk power facilities. Retail distribution costs are not included.

Bulk power transmission network. The transmission lines and switching stations that connect the principal sources of power to the main-load centres and to each other.

CANDU. A Canadian-developed nuclear-power reactor system. The name is derived from CANada Deuterium Uranium, indicating that the moderator is deuterium or heavy water and that the fuel is natural uranium.Pressure tubes containing the fuel and coolant run the length of the reactor vessel.

Circuit. A set of conductors in a closed loop – three for a three-phase system, two for a single-phase system – through which electric current is intended to flow.

Component. One of the many elements of a power system, e.g., a generating unit, a transmission line, a circuit breaker, etc., and also one of the many items of equipment included in each element, e.g., conductors, insulators, relays, etc.

Cycle. The period of time required for alternating voltage or current to reach a maximum from a zero value, reverse and reach a maximum reverse value, and then return to a zero value. On a 60 Hz (hertz) system this time is 1/60 of a second.

Demand load. The maximum value of an electrical load in terms of either power or energy.

Direct current (D.C.). Current that, under normal conditions, flows in one direction only.

Distributing station. A group of electrical components that accepts power at subtransmission voltage and re-distributes the power at a lower voltage for utilization by street feeders.

Distribution. The process used for transmitting power from the area supply stations to the ultimate users of power.

Dynamic stability. The ability of the power system to withstand large or small oscillations of power over an extended period of time without undue fluctuations in system voltage or system frequency.

Electric power. The rate of transferring electric energy, expressed in watts, kilowatts, or megawatts.

Energy demand. A customer's demand for electric energy from a utility.

Forced outage. The breakdown or loss of a major system component due to some cause which requires the electrical isolation of the component from the remainder of the power system.

Generating station. A centre for producing electrical energy.

Grid. In the utility context, an interconnection of electrical circuits.

Heat pump. A thermodynamic term used in this publication to describe the operation of refrigerators. It can be reversed to supply heat to a system and it has some energy-conservation features.

Heat rejection. A term used to indicate waste-heat released from a thermal station, usually via the process of cooling water.

Hertz (Hz). The unit of alternating current frequency, one cycle per second.

Horsepower (HP). This is a measurement of the rate of doing work, and is basically the amount of work required to raise 550 pounds one foot in one second. The metric equivalent is 746 W or 0.746 kW.

Hydro-electric generating station. A power station in which the force of falling water spins turbines which in turn drive electric generators.

Kilovolt (kV). One thousand volts; a unit of electromotive force. 1 kV = 1000 V.

Kilowatt (kW). One thousand watts; a unit of electric power. 1 kW = 1000 W.

Kilowatt hour (kW•h). A unit of energy equal to the work done when energy is transferred at the rate of one kilowatt for one hour.

Load. A device that receives power, or the power delivered to such a device. Also, the amount of power or energy consumed by customers.

Megawatts (MW). One million watts or one thousand kilowatts, a means of indicating the electrical power rating of large motors and generators.

N.E.B. National Energy Board.

Net generating capacity. Available capacity after all energy considerations involved in generation are subtracted.

Network. The term used to describe a bulk-power electrical system and the transmission lines that connect the system generators and loads together.

Nuclear energy. The energy liberated by a nuclear reaction such as fission.

O.E.B. Ontario Energy Board.

Outage. The term used to describe a failure of a component of the electric power system.

Peak load. The maximum power taken or produced in any period of time (e.g., in a day). It may be measured in terms of instantaneous power, or the average power over some interval, e.g., 20 min.

Per-capita use. The use based on population (all individuals considered equally).

Power. The rate of doing work, or, in an electrical network, the rate at which electrical work is being supplied. Sometimes the word is used in a general sense to cover both power and energy, but this loose usage should be avoided in technical work.

Power grid. A power grid from which electric energy may be exported or imported.

Rate structure. A scheme for charging customers. Present schemes have reduced sliding rates for larger purchases.

Resistance. The property of an electrical conductor which is indicative of the ease with which an electrical charge can flow in the conductor. The lower the resistance, the easier it is to transmit electricity.

Switching station. A station whose function is to interconnect transmission lines through circuit breakers. Its purpose is to subdivide the transmission system to limit the amount of the system that is lost as the result of a fault. See "Outage" above.

Transformer. A device for changing the voltage of an electrical network.

Transformer station. The place in a transmission system where the system voltage is changed either up or down by the use of transformers.

Transmission line. The facilities for transporting electrical energy from one plant to another. They may be overhead or underground.

Transmission losses. The loss in the system: the difference between primary energy generated and the energy delivered to customers.

Volt (V). A unit of electromotive force.

Voltage. The number or units of volts a circuit possesses.

Waste heat. The non-usable heat resulting from thermodynamic restrictions on efficiency.

Watt. The unit of electrical power that represents the power used when one ampere flows through a circuit with a potential of one volt.

Wind power. The generation of electrical power using wind-driven generators.

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Part 4, Water

Table of Contents

Introduction 2

1. Water – Our Most Precious Resource 2
2. A Quantitative Approach 17
3. Home Activities 20
4. Volume and Energy Accounting and Extensions 28
5. Man's Intervention in the Water Cycle 36
6. Action Plans 46
7. Support Material 47
8. Bibliography 48

★ A star beside the text indicates an investigative activity for students.

Illustration by Greg McEvoy, Student, High School of Commerce, Ottawa, 1977

Introduction

About two-thirds of the human population on this planet do not have an adequate supply of water. This fraction is increasing. Yet, from space, earth appears to be a blue planet due to its surface being three-quarters covered by water! Although much of it is salt water, nature's dynamic processes in the water cycle provide fresh water through precipitation.

What's the problem? Do people tend to live where fresh water is *not* available?

The Great Lakes system is the largest supply of fresh water in the world. A lack of water, then, and associated problems are virtually of no concern to the fortunate people living in Ontario; and this is precisely why water is our most-abused resource.

In a way, this flagrant use and misuse of water is typical of our society and its current consuming/discarding life style. Perhaps it is the fact that this prime necessity of life, even before food, is so plentiful in our environment that we have, in general, not developed the ingrained habit of conservation.

At first, it may not seem that conserving water is conserving energy – but think about it!

In this unit, you will learn about the role that water plays in our society through a series of activities. These activities will help you see how water-conservation practices have a broad significance in the conservation of energy in general, and how your home is linked up through water to a multitude of energy-converting processes in our society.

1. Water – Our Most Precious Resource

Water is all around us – as a liquid and as a vapour. We exist because of water; are ourselves part water; cannot live without water. Yet how much do you know about water; where it comes from, where it goes, how it is used, or even how much of it is there?

In Ontario, we are fortunate in having available a great abundance of fresh water. The history of our province is linked to the presence of this water, and it was by travelling through the lakes and along the rivers that our first explorers discovered much of our country. How Ontario has been developed can be traced through the manner in which water has been discovered, developed and used to enable us to live, grow crops and manufacture goods.

By this constant use of our province's water we are more fully able to develop our agricultural and industrial economy, and have become one of the major suppliers of produce to the world.

But, like any other commodity, the more water that is used the more it must be maintained, protected from abuse, and controlled so that an adequate supply is always assured.

From Ministry of the Environment, Ontario, *The Water Story* (Toronto: Queen's Printer, 1968), p. 2.

How We Use Water

It Could Never Happen to Us!

★ After reading the article below, answer the following questions:

1. What are some factors that affect the supply of water?

2. What are some factors that affect the demand on water?

3. Why don't people conserve water, especially when warned to do so?

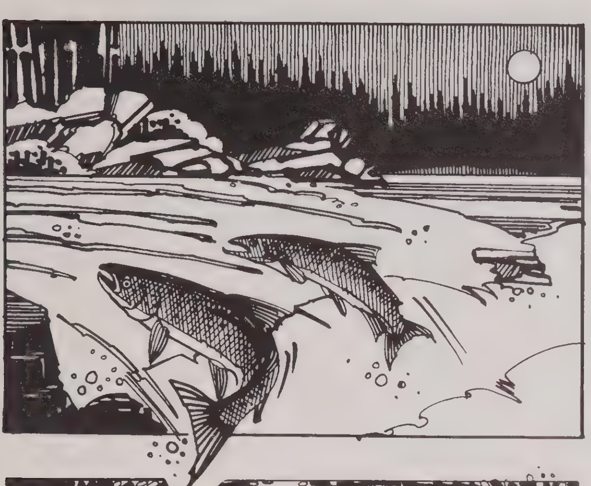
4. What role did politics play in an attempt to solve the problem?

5. In the article, what is the "glory" role that water plays?

Water shortage hits St. John's
By Bren Walsh

> *St. John's* – If there's one thing no citizen of St. John's would have expected as recently as five or six years ago it's a water shortage – yet that's what's facing a large section of the western part of the Newfoundland capital.
>
> St. John's, with five lakes within its city limits and scores of others within "a gunshot and a bit", is consuming more water daily than the reservoirs can replace under existing conditions.
>
> Following a winter with a less than average snowfall and consequently a disappointingly small spring runoff came a spring marked by less than normal rainfall.
>
> The result is that the reservoir into which the western part of the city is tapped – Petty Harbour Long Pond – is down by about 0.5 m (a foot and a half) while consumption, in spite of warnings from City Hall of the danger, continues to rise.

1



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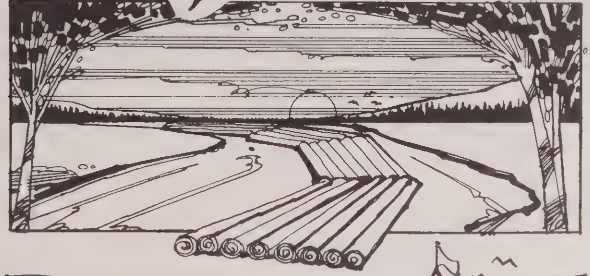

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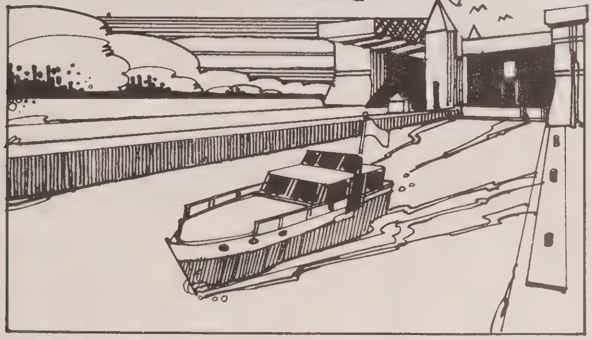

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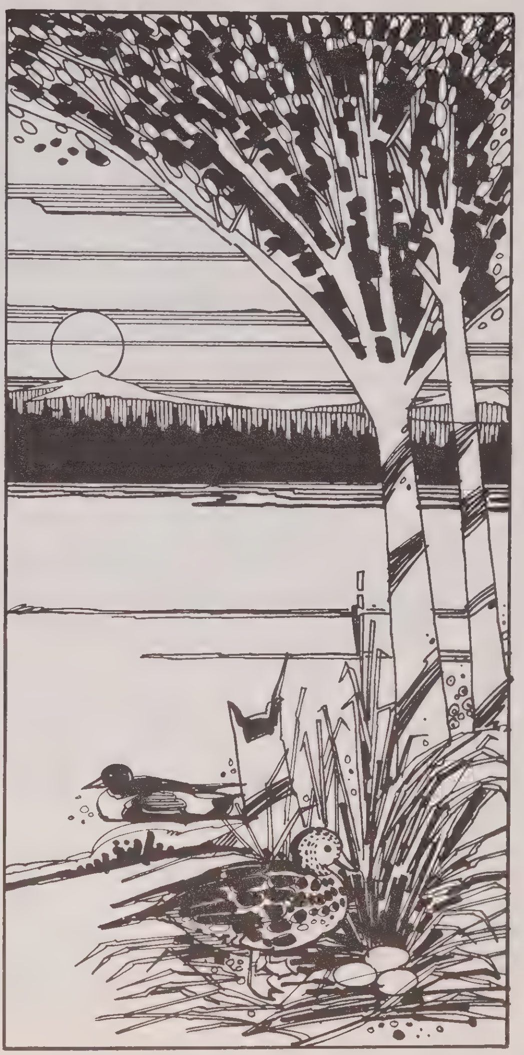

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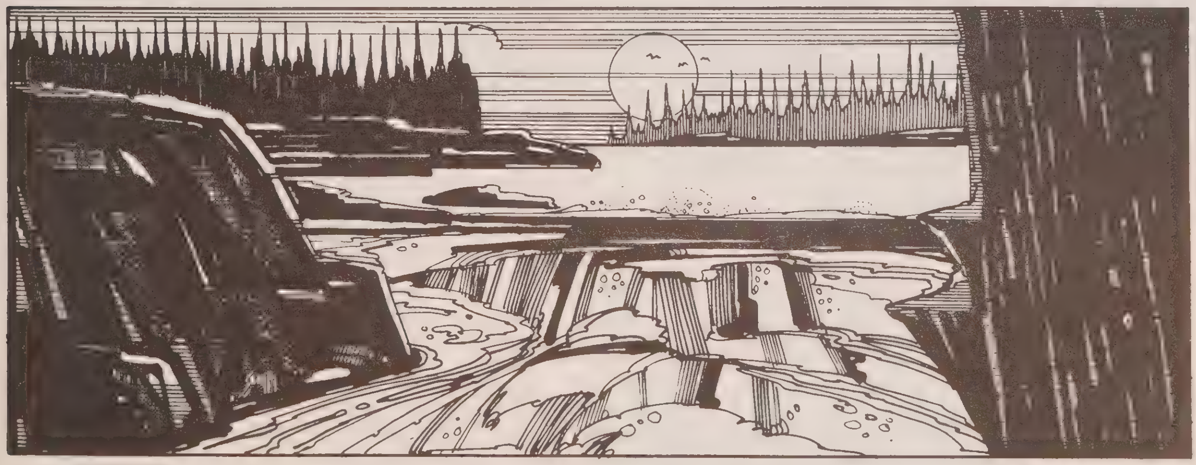


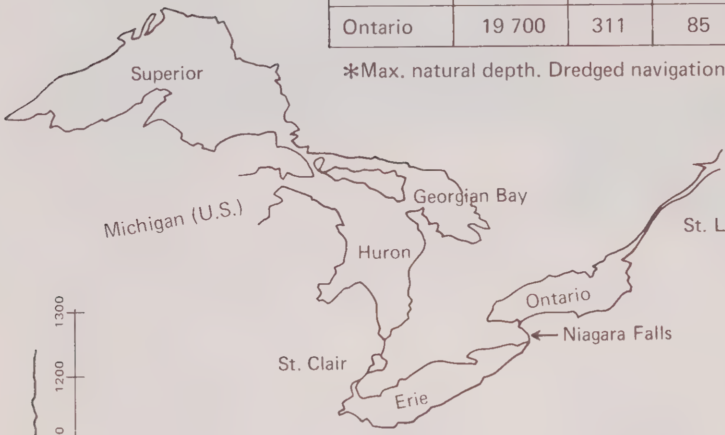
★ For each illustration, list the principal use being made of the water shown. Are there any major areas of water use that are not illustrated?

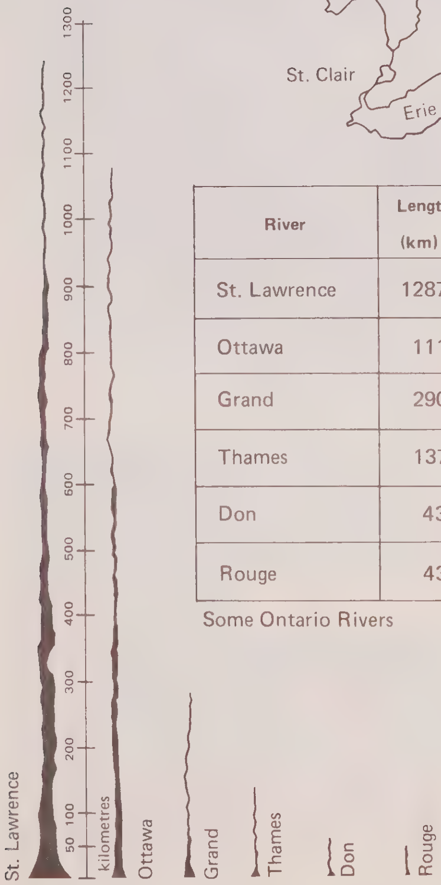
Figure 4.1

Water in Ontario

Lake	Area of water surface (km²)	Length (km)	Width (km)	Depth av. (m)	Depth max. (m)	Natural Outlet
Superior	82 400	616	257	148	406	St. Mary's River
Michigan	58 000	517	190	84	281	Lake Huron
Huron	59 600	398	163	59	229	St. Clair River
St. Clair	1 270	42	39	3	* 6	Detroit River
Erie	25 700	388	92	18	64	Niagara River
Ontario	19 700	311	85	86	244	St. Lawrence River

*Max. natural depth. Dredged navigation channel = 8.4 m.



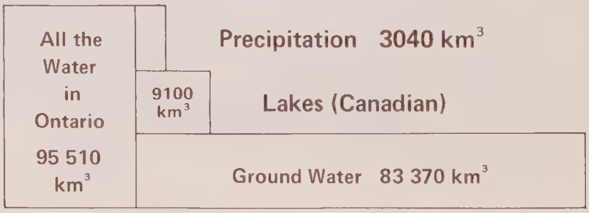


River	Length (km)	Drainage area (km²)
St. Lawrence	1287	1 760 000
Ottawa	111	148 000
Grand	290	2 720
Thames	137	5 830
Don	43	360
Rouge	43	106

Some Ontario Rivers

Annual Precipitation

Lake Basin	Av. (mm)	Max. (mm)	Min. (mm)
Superior	740	910	580
Michigan	790	940	560
Huron	790	990	660
Erie	860	1090	610
Ontario	860	1090	710



Source: Ministry of the Environment, Ontario, *My Water Book* (Toronto: Queen's Printer, 1968), p.7.

On Tuesday, after four days of reduced consumption resulting from an exodus from the city for the three-day Discovery Day holiday weekend, consumption from Petty Harbour Long Pond was measured at about 24 thousand cubic metres (5.3 million gallons) – and that's about 5.9 thousand cubic metres (1.3 million gallons) more than the pond can provide on a sustainable yield basis.

Already City Council has put in emergency regulations banning the private washing of cars using city water, permitting commercial car washes to operate only two days a week and limiting lawn-sprinkling to half an hour each evening.

Still the water levels drop, there's little evidence that the average citizen is taking any pains to conserve and the dry spell continues with record high temperatures being recorded.

The problem is a temporary one, since work has already begun on an extension to the water system – using nearby Bay Bulls Big Pond, which is scheduled to be on stream in little more than a year. When that happens the engineers estimate the city will be well away for at least a quarter of a century.

The catch is how to make the present inadequate reservoirs (inadequate because of the population growth of the past few years) last until that extra source is available.

The concern is not simply that citizens may not have enough water to spray their lawns, wash their cars and provide the daily bath water – the fact is that, unless the comparative drought ends or west enders suddenly become conservation-conscious, a large section of the older city could be without adequate water pressure for fire-fighting purposes in as little as a month from now.

In a wooden city such as the old St. John's still is that's enough to send shivers down the backs of everyone. It's certainly enough to make City Council prepared, albeit reluctantly to impose water-rationing almost any day.

While the past winter produced little snow it did bring extremely cold temperatures and the citizens of St. John's look forward to a sunny, warm summer.

That desire is, if anything, a bit stronger than usual this year with the city playing host to the Canada Summer Games.

Nevertheless, the stark reality is that if present conditions are unchanged in the next few weeks the city will at best face severe water rationing and at worst face the threat of a major conflagration with inadequate water pressure for fire-fighting.

It has been 78 years since the last major fire swept through a large slice of St. John's. Lack of water pressure could magnify a routine fire alarm into a replay of that disaster.

From *The Globe and Mail,* Toronto, July 3, 1976.

What Do You Think?

★ As a class or group, read and discuss the following three statements. Refer to the section on values continua on p. 7 of Part 2, Space Heating, and produce a values continuum for each statement to clarify your views. Keep a list of the arguments used "for" and "against" the conservation of water.

1. Ontario will never experience problems with regard to the availability of fresh water. The Great Lakes are the largest supply in the world; in addition, there are thousands of small lakes, all fed by many rivers. See figure 4.1.

2. The amount of water used by industry and other non-residential users is so much larger than that used in the home or in school that conservation programs in these areas are just "a drop in the bucket", so to speak.

3. The energy required to process water and deliver it to the point of use is very small. Reducing water use does not really assist in conserving energy to any great degree.

All Living Things Contain Water

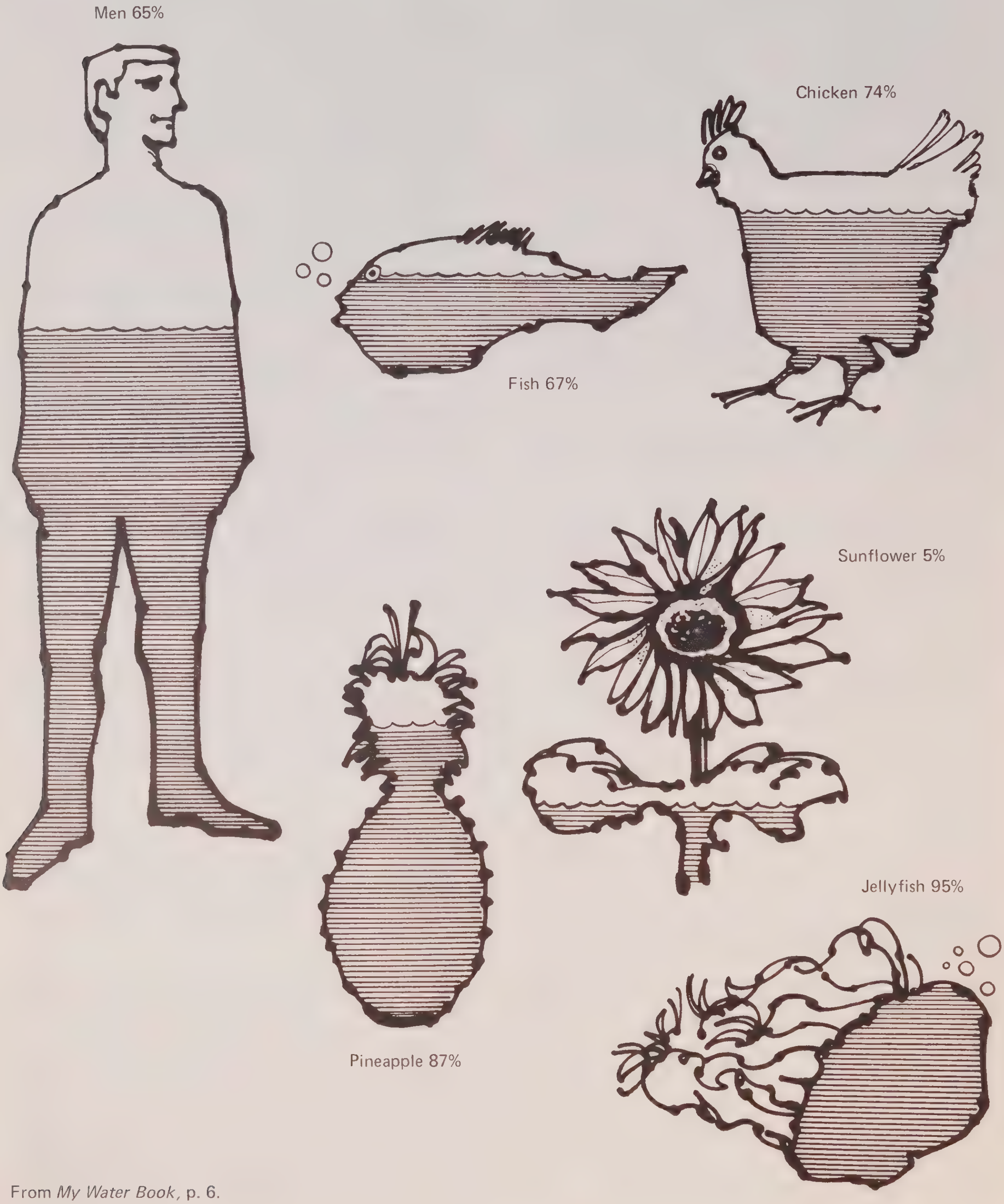
> Much of what we are is water. The human body cannot exist without water; and is actually more water than anything else, between 65% and 70%. Many fruits and vegetables are mostly water – and most watery of them all are the watermelon and the cucumber.
>
> Quite a lot of the water in the human body is lost through evaporation at the surface of the skin. More is lost through the various glands that secrete fluid and keep our eyes washed and lubricated, or our mouths moist, and our noses clean. This water is replaced in the body from fluids that we drink. Excess moisture that we drink and do not need is wasted from us.
>
> Ministry of the Environment, Ontario, *My Water Book* (Toronto: Queen's Printer, 1968), p. 6.

★ List the ways in which you maintain water in your body. Include pure water, water in liquids, and water in solids. Estimate the percentage (%) contribution of each of these three categories, and through research in your library resource centre check out your opinions.

★ Keep track of everything you eat and drink for one day, including approximate amounts in grams. By referring to water-content percentages, as in Figure 4.2, attempt to determine what percentage of the total intake by mass was water. What volume of water did you consume (1 kg of water has a volume of 1 L)? Refer to table 4.3 on p. 17 for assistance in changing imperial units to metric units.

> *The Water We Drink Is Not Just Water!*
> Each day, each one of us requires about two litres of water in order to sustain our body functions. Some of this fluid we obtain in the food we eat, some in the variety of fluids we drink. The body has its own highly efficient water cleansing system that filters out many of the impurities naturally present in all except so called chemically pure water. The capacity of this bodily machine is limited, however, and it cannot always protect us against disease-causing micro-organisms. For this reason, water supplies for domestic purposes must be free from amounts of chemical substances and micro-organisms that could constitute a health hazard. In addition, drinking water should also be as aesthetically attractive as possible. It should be colourless, tasteless, and odourless.

Figure 4.2



From *My Water Book*, p. 6.

To ensure that drinking water has these desirable qualities, the Province of Ontario has set standards or objectives regarding the limits for certain substances in our water.

If the following substances appear in our drinking water at a level higher than the established objective, the water supply should be rejected. If not, there could be adverse effects on health.

Table 4.1

Substance	*Permissible Concentration milligrams per litre (mg/L)*
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium ($Cr^{6}+$)	0.05
Cyanide (CN)	0.2
Fluoride (F)	*
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

*See the section on fluoride.

Fluoride
When fluoride is naturally present in drinking water, the concentration should not average more than 1.2 mg/L. The presence of fluoride in concentrations of more than 2.4 mg/L constitutes grounds for rejection of the supply.

Where fluoridation (supplementation of fluoride in drinking water) is practised, the fluoride concentration recommended is 1 mg/L with a permissible operating range of 0.8 mg/L to 1.2 mg/L.

Fluoridated and defluoridated supplies should be sampled with sufficient frequency to determine that the desired fluoride concentration is maintained.

From Ministry of the Environment, Ontario, *Drinking Water Objectives* (Toronto – Queen's Printer, 1976), pp. 10-11.

★ The following table provides some of the reasons behind the limits proposed in the above list. Why are some substances listed above not included below? Why are some substances listed below not included in the water quality table above?

Table 4.2

Symbol	Substance	Source	Effect
SiO_2	Silica	Clay minerals, opal rock minerals.	Forms scale on boilers and steam turbines, inhibits pipe corrosion.
Fe	Iron	Igneous and sandstone rocks, iron pipes, pumps, storage tanks, etc.	Stains plumbing fixtures, laundry and cooking utensils, spoils water taste and colour.
Mn	Manganese	Soils and sediments, metamorphic and sedimentary rock.	Has undesirable taste, leaves deposits on food during cooking, stains plumbing fixtures and laundry.
Ca	Calcium	Gypsum, calcite, clay, limestone, rock minerals.	Combines with other minerals to form scale in boilers; inhibits formation of soap suds.
Mg	Magnesium	Limestone, clay, rock minerals.	Same effects as calcium.
Na	Sodium	Clay, sediments, industrial wastes, rock minerals.	Produces scale and corrosion in boilers; combines with potassium carbonate to cause wood deterioration.
K	Potassium	Mica, clay, rock minerals.	Same effects as sodium.
HCO_3	Bicarbonate	Limestone.	Combines with other minerals to form scale in pipes.
CO_3	Carbonate	Limestone.	Same effect as bicarbonate.
SO_4	Sulphate	Oxidation of sulphide ores, sulphate minerals, industrial wastes.	Forms scale, causes bitter taste, may be cathartic.
Cl	Chloride	Sedimentary and igneous rocks, salty water forced upstream into tidal estuaries.	Has a salty taste, can be harmful to health.
F	Fluoride	Rock minerals, fluorite, mica.	Increases resistance to tooth decay but, in excess, may cause mottling of tooth enamel.
NO_3	Nitrate	Atmosphere, legumes, plant debris, animal excrement, nitrogenous fertilizers, sewage.	Has a bitter taste, harmful in excess, especially to infants.
$CaCO_3$	Calcium Carbonate	Limestone.	Inhibits formation of soap suds, forms an insoluble scum or curd in washing machines.

Source: *The Water Story,* p.13.

★ Have one member of the class, or your teacher, obtain a recent analysis of the water used in your community and compare it to the above lists. Is the water you drink fluoridated? Drinkable water is referred to as "potable water".

Do the following activity, but do not attempt to answer each of the questions completely at this point.

★ Put 1 L of water in a container and look at it! Where did it *really* come from? How did it get from there to you? What happened to it on the way? How many litres do you think you and your family use in a day, week, month, year? Make a guess. Now get rid of the water. What did you do? Where did it go? Where will it finally end up? Was your decision of how to dispose of it a good one? Did you just waste another litre of water? *Do you think you wasted any energy?*

The problems posed by the above activity are ones that you are going to look at closely throughout the rest of this unit. Before getting down to work, however, a game called "Splash" is provided so that you can start thinking about your use and abuse of water. Section 2 will get you started on a scientific study of the use of water in your own home.

Splash

★ Splash is an energy-conservation game for the entire class or for the family – from age five to adult. It is easy to play, lots of fun, and, most important, it will help you learn some of the basics of water-energy conservation.

The game package includes:

1. rules of the game
2. draw-cards
3. markers
4. complete playing surface

All you need to provide is a die. (If you don't have one, use a sugar cube with inked-in dots.)

To make the game-board sturdy and longer-lasting, paste it to a piece of cardboard. Do the same with the markers and the draw-cards.

Rules

1. Each draw-card is either a good or a bad conservation idea. Most cards indicate which is which on the back. A few don't. You, as a group, must decide on those. You must also decide how good or how bad each idea is. Rate each one on a scale of 1 to 10, and mark it on the back. For example, if you as a group think the idea is a minor one, mark it "Advance 2" or "Go back 2". If you think the idea is a major one, mark it "Advance 10" or "Go back 10". Try to use all the numbers.

As you proceed through the project, you will learn the relative values of ideas and you may change the numbers you put on the draw-cards.

2. Shuffle all the draw-cards and place them face up on the table.

3. Each person chooses a marker. Place it to the left of number one – just off the board.

4. Each person shakes the die (use one only) – highest number begins.

5. If you land on a draw-card space, pick up the top card from the pile and move according to the value indicated on the back. For example, if you land on "3", and the next draw-card is marked "Advance 4", you move to number seven. If it is marked "Go back 4", you go back to the beginning and you then have to roll a six to get back into the game.

6. Place the card you picked face down at the bottom of the pile. When all the cards are drawn, reshuffle them and place them face-up again.

7. If you land on a picture, follow the pipe in the direction shown.

8. The first player to reach "100" (a smiling face) wins the game. *You must throw the exact number to win.* For example, a player on "99" must throw a one, and so on.

9. When there is a winner, the other players can play for second or third position if they wish.

10. Two or more players can land on the same number at the same time.

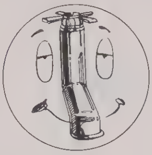
Splash

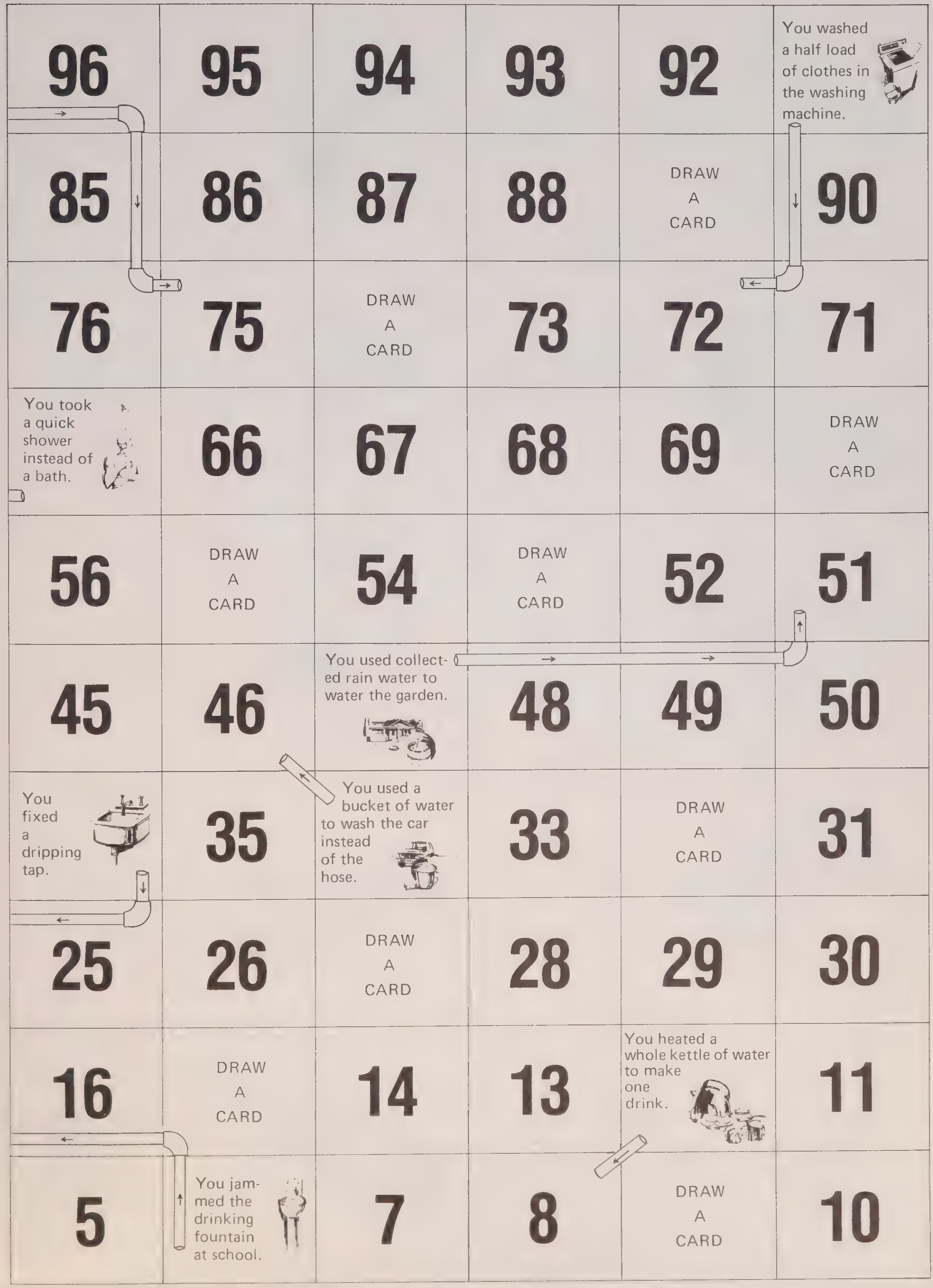
THIS GAME'S
ALL WET!

MARKERS

Cut out markers and paste
onto cardboard circles.

Cut along this line and paste onto a piece of cardboard

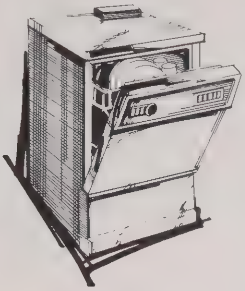
	99	98	You took a bath with too much water.
81	82	DRAW A CARD	84
80	79	78	DRAW A CARD
61	62	63	64
60	59	58	57
41	42	DRAW A CARD	44
DRAW A CARD	39	38	37
21	22	23	DRAW A CARD
DRAW A CARD	19	18	17
1	2	DRAW A CARD	4



96	95	94	93	92	You washed a half load of clothes in the washing machine.
85	86	87	88	DRAW A CARD	90
76	75	DRAW A CARD	73	72	71
You took a quick shower instead of a bath.	66	67	68	69	DRAW A CARD
56	DRAW A CARD	54	DRAW A CARD	52	51
45	46	You used collected rain water to water the garden.	48	49	50
You fixed a dripping tap.	35	You used a bucket of water to wash the car instead of the hose.	33	DRAW A CARD	31
25	26	DRAW A CARD	28	29	30
16	DRAW A CARD	14	13	You heated a whole kettle of water to make one drink.	11
5	You jammed the drinking fountain at school.	7	8	DRAW A CARD	10

Drawcards

You washed a few dishes in the dishwasher instead of the sink.

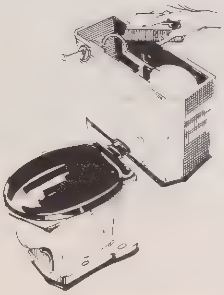


You washed your hair in the lake.

You watered the lawn with the hose and left it on too long.

You made yourself a hot drink, using just enough water in the kettle for one cup.

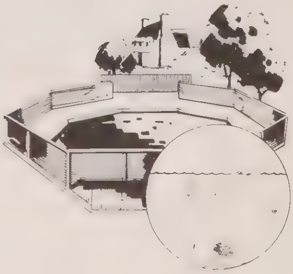
You put a brick in the toilet tank



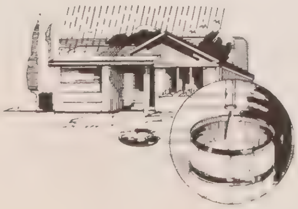
The outhouse was moved away from the lake.

Your father took the car through the car wash.

A lot of grass and sand were thrown into the pool and now it has to be cleaned out.



You save rain water to water the garden.



One of your friends jammed the drinking fountain at school and you didn't try to unjam it and turn it off.

Go back ________

Advance ________

Advance ________

Advance ________

Go back ________

Go back ________

Advance ________

Go back ________

Go back ________

Advance ________

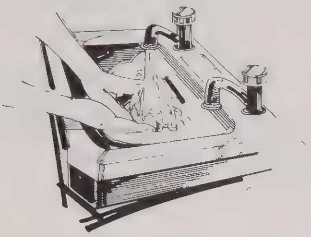
Go back ________

Advance ________

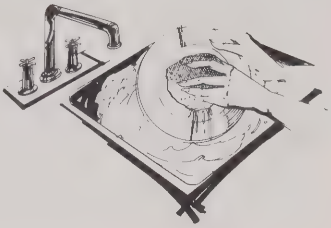
Advance ________

Drawcards

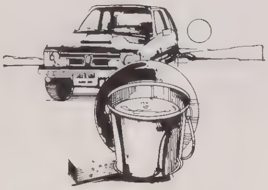
You washed your hands in running water.



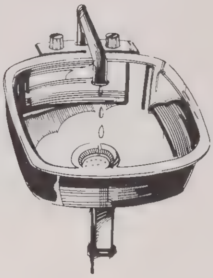
You washed the supper dishes in the sink instead of in the dishwasher.



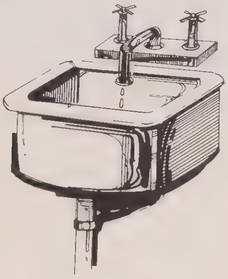
You washed the car with a bucket of water instead of the hose.



You left the tap dripping after you brushed your teeth.

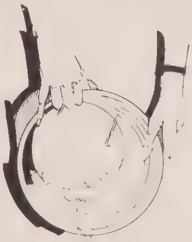


You turned off a dripping tap.

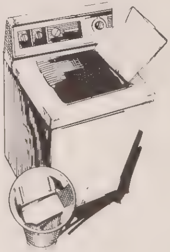


You took a quick shower last night instead of a bath.

You poured the dirty dishwater into the lake.

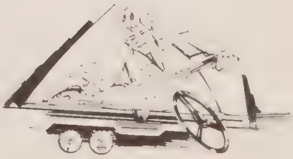


Your mother washed the clothes in the washing machine and she only had a half load.



You took a bath using lots of hot water.

You washed the car with the hose.



Advance ________

Go back ________

Go back ________

Advance ________

Go back ________

Go back ________

Advance ________

Go back ________

Advance ________

Go back ________

Advance ________

Advance ________

Go back ________

Go back ________

2. A Quantitative Approach

The best way for you to really get a feeling for the amount of water you use is to make some measurements. The most direct approach is to determine the *volume* of water used in each activity you do.

Measuring Quantities of Water

Until metric conversion has been accomplished in water systems in Canada, you will still encounter the British system of measurement, including such common units as: gallons, quarts, or cubic feet. In the case of larger quantities, two very useful terms are:

1. gallons per day (gpd) – the volume of water used in twenty-four hours;

2. gallons per capita per day (gpcd) – as above, but per person involved in the use.

As we are in the process of converting to the metric system of measurement, all units used in this part will be metric. Unit conversion will be necessary in some cases, but you will soon realize that metric units are very convenient. The following table will provide you with the majority of the conversions you will need.

Table 4.3

1 gal. = 4 qts. = 8 pts. = 160 oz. = 16 cups = 277.3 in.^{3} = 0.160 ft.^{3} = 4.54 L

1 ft.^{3} = 1728 in.^{3} = 6.23 gal. = 28.3 L

1 L = 1000 cm^3

1 m^3 = 1000 L

1 gal. of water has a mass of 10 lb. or 4.54 kg

1 ft.^{3} of water has a mass of 62.4 lb. or 28.3 kg

1 L of water has a mass of 1 kg

1 m^3 of water has a mass of 1 t (tonne)

L/d (Lpd) means litres per day

L/d (capita) (Lpcd) means litres per capita per day

L/a (Lpa) means litres per year (annum)

m^3/a (m^{3}pa) means cubic metres per year (annum)

Four Ways to Measure Water Volumes

★ 1. If your water supply is provided by a water utility company, it is likely that you have a water meter. Find your water meter and determine the units in which it measures and the smallest unit division on the scale. Have someone use some water and watch how the dials or needles change position. Can you read or estimate a fraction of a cubic foot or a gallon? You may live in an area such as Mississauga where new meters show the volume of water in cubic metres (m^3). The illustration below shows a common type of water meter with a variety of different faces.

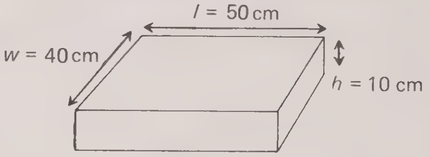
The meter gives the total volume. To determine the volume used, you must subtract the "before" reading from the "after" reading. Remember to convert!

1 cubic foot – 1 ft.^{3} = 28.3 L
1 imperial gallon = 1 gal. = 4.54 L

The meter readings will be satisfactory for large volumes. For smaller volumes, read on.

★ 2. Use a ruler to estimate a rectangular volume equal to the one you are trying to determine. This is useful in estimating the volumes of sinks and bathtubs. Measure in centimetres and convert the volume to litres. The accompanying illustration shows you how.

Figure 4.3



$$\text{Volume} = \frac{(l \times w \times h)\ \text{cm}^3}{1000\ \text{cm}^3/\text{L}} = \text{Volume in litres}$$
$$= \frac{50\ \text{cm} \times 40\ \text{cm} \times 10\ \text{cm}}{1000\ \text{cm}^3/\text{L}}$$
$$= \frac{20\,000\ \text{cm}^3}{1000\ \text{cm}^3/\text{L}}$$
$$= 20\text{L}$$

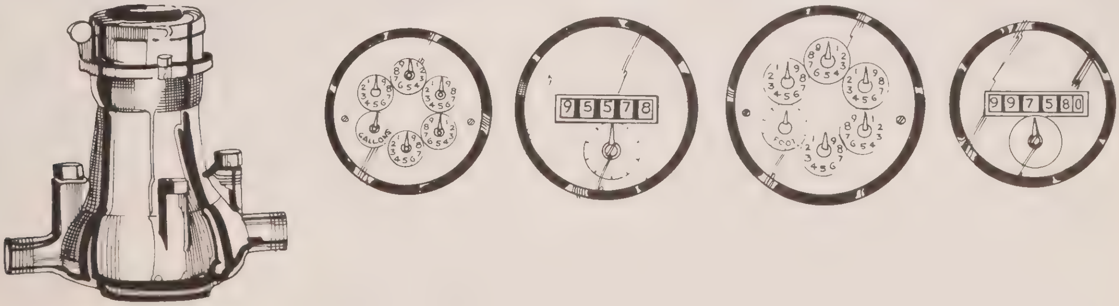


Table 4.4

Water-Consumption Record Sheet						
Date	Meter Reading (unit on meter)	Number of Days Since Previous Reading	Volume Used (unit)	Volume (Converted to litres)	Volume Used Per Day (litres per day)	Change (+) (−) (in litres)

★ 3. Determine the maximum volumes (in litres) for each of the various sinks in your home.

★ 4. Obtain some containers that you know the size of (three-quart milk jug, gallon paint can, quart bottle) and convert them to litres, or use a felt pen to mark a certain volume on them in litres.

Special appliances, such as a dishwasher, clothes washer, or water heater, may have the volumes they use marked on them. These volumes may also be given in the manufacturer's specifications that come with the device.

Making Use of Your Water Meter

The following activities are for those who have a water meter that is readily accessible. This includes the water meter for the school.

★ At the same time each day for one week (or month), read and record the water-meter reading in your home. Remember to convert to litres. Plot a graph for the week. Determine the average litres per day used and divide this amount by the number in your family to get the average litres per capita per day.

This activity can also be done for your school. (Arrange for only one person to read the meter each day!) Do you know your school population? Calculate the average litres per capita per day used.

If you live in a multiple-family dwelling such as an apartment block, this activity could be carried out for the whole building. (Do you know the building superintendent or landlord?)

★ See if you can conserve! Get into the practice of monitoring your use of water. Set up a chart as in table 4.4. Entries should be made on a daily, weekly, or monthly basis. This table will be extended to energy estimates later in this unit.

From the table, plot a graph of the volume used (litres per day) for each date. Put the months of the year (or days of the month) along the horizontal axis. You will notice that the litres used per day do not remain constant; they change or fluctuate.

★ 1. Read your water meter daily for a week and record the total volume used.

2. Institute a few water-conservation practices and for the next week take daily readings again.

3. Calculate the water saved during the second week in litres. What percentage of the first week's volume did you cut back?

4. Continue weekly readings for another four weeks. Are your conservation practices becoming a habit?

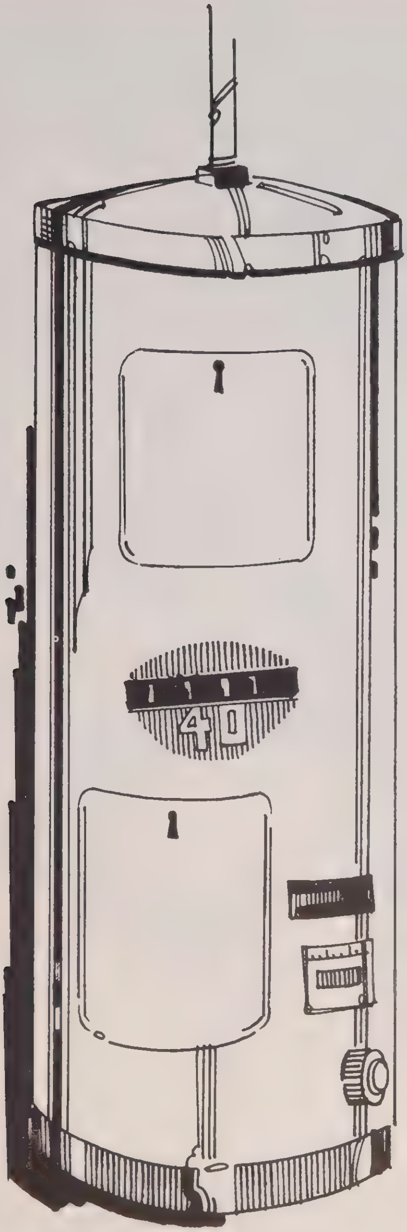
5. Estimate the number of homes in your community. Assuming your calculations in (3) are "average", what volume per week (year) could be saved in your community?

A major problem in water supply is to accommodate fluctuations in the *rate* at which water is used in the community.

★ Predict when peaks in the rate of water use would occur in a community over the following periods: one day, one week, one year. Support your ideas with arguments. Sketch the type of graphs you would *expect to see* for the system supplying your water. (Have your teacher contact the appropriate people in your local water utility department to see if sample graphs can be obtained.) How is a supply system designed to accommodate these changes? How do you know if your supply system is having trouble giving you the water you are asking for?

★ Develop a list of practices that would reduce the "peaking" of water use in a residential community. How could these be instituted or enforced?

In a big city, you can often tell the precise time a major television event (like a hockey game) is over by looking at the water-consumption graph for that day! Explain why.



Keeping Track of Hot Water

Some of the cold water entering your home or school is taken off of the service line and heated in a specially designed water heater.

Note: If the heating system consists of hot water circulating through a series of radiators, there will be water in a "jacket" around the furnace. This is *not* the water heater being referred to in this unit.

★ Locate the water heater in your home and determine:

1. the capacity (if gallons, convert to litres)

2. the method of heating the water (electricity, gas, or oil)

3. the location of the thermostat that controls the water temperature

4. where the cold water enters and the hot water leaves (touch the pipes!)

★ Determine whether:

1. the water heater is insulated. (If it has a metal cover, which is cool, it means the insulation is underneath.)

2. the visible hot-water pipes leaving the tank are insulated.

3. there are *any* hot-water taps in the house that drip or leak.

Draw conclusions based on your findings. What action should be taken?

★ The thermostat on the tank causes the heater to come *on* when the water in the tank cools below a certain temperature and to shut *off* when the temperature reaches a certain *set* maximum temperature.

Determine the maximum temperature of the hot water produced by your heater by placing a thermometer in the hottest water you can get from a hot-water tap near the heater. Check this against the thermostat setting on the tank.

★ Think carefully about the following and do some research in the library. Then take action!

1. In what jobs in your home is *pure* hot water used and what is the maximum temperature needed? (See some of the activities in Section 4.)

2. Have your parents reduce the thermostat setting to this temperature or to a temperature just adequate for the job to be done. Check again with a thermometer.

Note: Contact your utility company (electricity, gas, or oil) to find out how to do this job before you start!

Quantities of Hot Water Used

1. If the activity you are working on uses *pure hot water,* then its volume can be measured by the methods referred to earlier. You can use the meter method, since cold water enters the tank as hot water leaves, and water from a hot-water tap *has been* heated even if it starts off cold!

2. If a mixture of hot and cold water is used in a job, run the cold water and measure its volume; then run the hot water until the desired temperature is reached and measure the total volume. Determine the volume of hot water by subtraction. (The order could be reversed. Should it be?)

★ Try out the above methods on the next bath taken by someone in your home. Use the two methods of determining the volume, then cross-check your calculations.

a) Estimate, by measuring, the rectangular volumes of hot and cold water used;

b) Read the water meter three times – before running any water, after the cold water is run, and after the hot water is run.

The methods of determining volumes of hot and cold water outlined above are very important to the rest of this unit, since the energy converted in using water is related directly to the volume used.

The next section deals with a large number of specific activities that make use of water. In each case, it will be necessary to *measure* (or estimate) the volumes of hot and cold water involved.

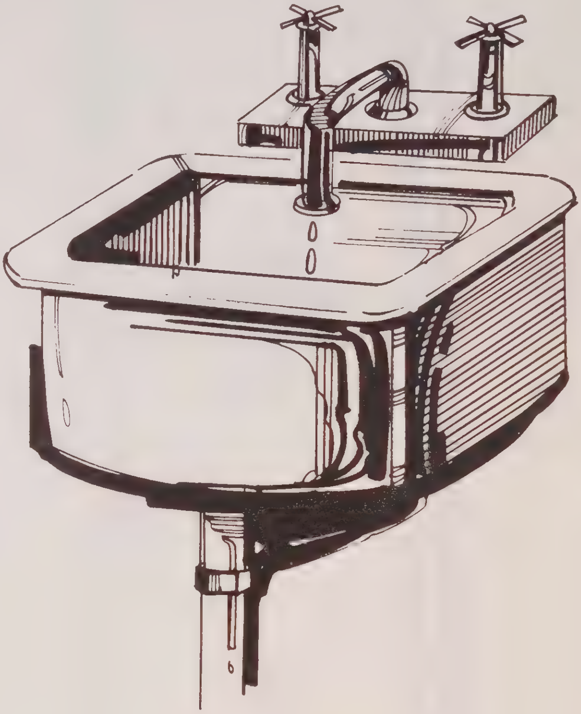
3. Home Activities

This is the longest section of the study since the activities deal with the variety of uses we make of water in the home. You will see "nothing new" here, but hopefully you will develop a new frame of reference in which to examine each situation.

While working through this section, consider each use of water from the point of view of "need". If you had to curb your use, which would be the "first to go"?

That Dripping Tap – Tips on Drips!

Before we start to measure the water you use in your home, let's see if there is some water you don't use! A dripping tap is a pure waste of both water and energy. Hopefully you don't have a dripping tap in your home. If you do, let's take a look at the problem – and the solution!



★ Adjust a cold water tap to produce a slow, steady drip (about one per second), and catch 15 min worth in a container. By measuring and multiplying, calculate the number of cubic centimetres of water per day that this drip will produce.

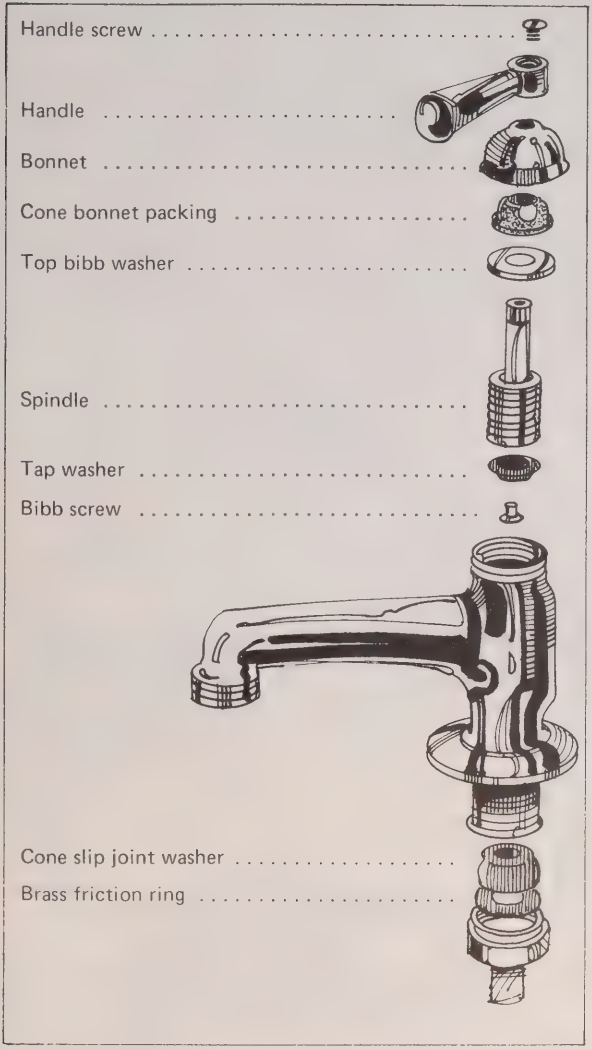
Convert to litres per day (L/d), litres per month (L/month), and litres per year (L/a). Calculate the volumes if the rate were two drips per second. Extend your calculations to see what the result would be if one out of every five homes in your community had a dripping tap.

★ If it is a hot-water tap that is dripping (and it usually is! – Why?), you can calculate the energy per week, month, or year that is just dripping away. Use your results from the previous activity and the calculations on energy consumption to heat water to help you. Refer to Section 4.

Note: Dripping taps are easily repaired. Find out (in the library) and then repair them.

Figure 4.4

Cut-Away of a Water Tap



Why a tap leaks
The compression tap is the most common type found in Canadian homes. The flow of water is regulated by turning a handle which is attached to a threaded spindle. When the spindle is turned down, the washer or disc attached to the bottom of the spindle is pressed tightly against a smoothly finished ring or ground seal, to shut off the flow of water. If this doesn't make a good contact, usually because of a worn-out washer, water will leak through.

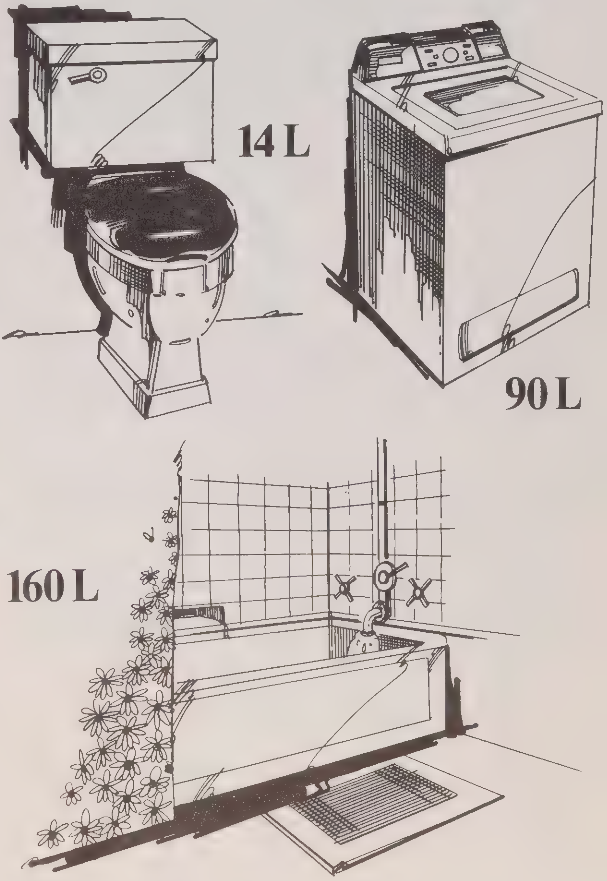
Source: Department of Energy, Mines and Resources Canada (Office of Energy Conservation), *100 Ways to Save Energy and Money in the Home* (Ottawa: Information Canada, 1975), pp. 88-9.

Use of Water in the Home

We will now take a look at where and how you use water. You will see that with just a little thought and effort, immediate savings can be made.

★ Produce a chart like table 4.5 (on p. 22). Start by listing each location in your home where water is available. Leave blanks so that you can add uses as you go through the activities in this section.

If you can do it, distinguish between the volume of hot and cold water in use where the water is mixed. Refer to "Quantities of Hot Water Used" in Section 2.



★ Now, make a list or chart similar to the previous one, but concentrate on the use you make of water outside your home. If you make use of the water that hits your roof, include it but don't worry about making volume estimates. (How could this be done?)

★ Before you start making all the measurements, guess at what you think are the top five uses of water in your home. Rank them and estimate the percentage each uses of the total water used in your home during a year.

★ Repeat the previous activity, but this time consider only hot water. What is the significance of a use that appears both in this list *and* in the previous list?

The following activities are designed, in part, to help you measure the volumes of water you use for the various jobs you listed in the above charts.

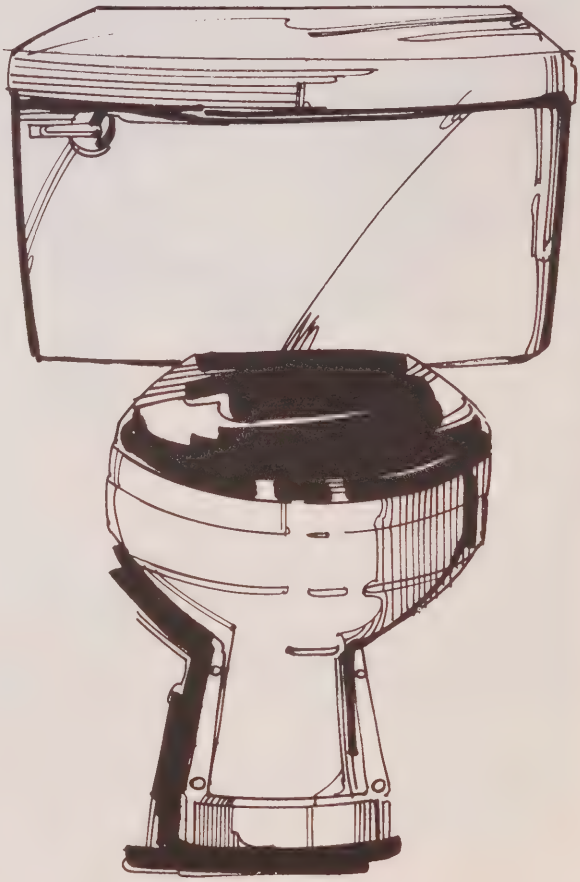
Table 4.5

Chart of Home Water Use

Location		Use Made of Water	Type of Water Used			Approximate Volume (litres *per use)*	Average Number of Uses *(Per Week)*	Approximate Volume in Litres Per Week
			Hot	Cold	Mixture			
Bathroom	Sink	– brushing teeth		*		?	?	?
		– washing hands			*	?	?	?
		– washing hair			*	?	?	?
		– etc.				?	?	?
	Toilet	– waste disposal		*		?	?	?

Toilet Training?

Using water to flush away human waste is really a rather recent phenomenon. In many countries, where water is in short supply, it's just not done. Is it an extravagant use of our water? Since it is treated water that is used, we are purposely polluting potable water!



★ Determine the volume of water (in litres) in your toilet tank. Refer to one of the three methods below. The volume you calculate is the amount of water used for each flush. Flush the toilet with the tank top off to see how it operates.

1. With the top off, note the high and low water-level positions in the tank. Ignore the water displaced by the various fixtures, and assume the tank to have a rectangular volume. Your calculations might be:

$$\text{Volume} = \frac{l \times w \times h}{1000} = \frac{48\text{ cm} \times 16\text{ cm} \times 17\text{ cm}}{1000\text{ cm}^3/\text{L}} = 13.1\text{ L}$$

2. Turn the water off under the tank, flush, then fill the tank to the high water mark using a container of known volume (e.g., a litre milk carton – about 10% less than a quart milk carton). Don't forget to turn the water back on again!

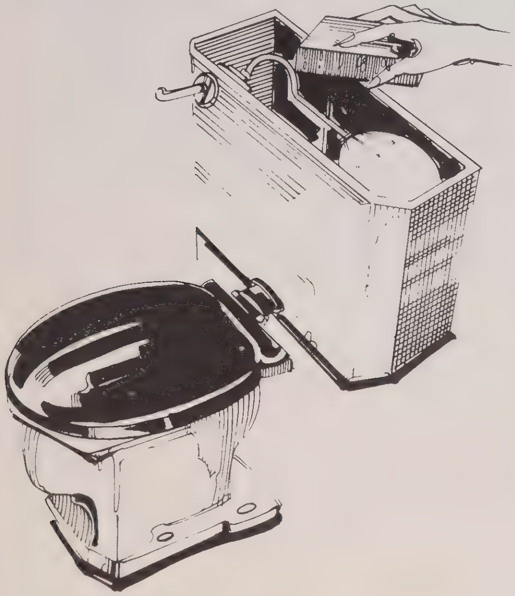
3. Use your water meter as explained in "Four Ways to Measure Water Volumes" early in Section 2.

★ Determine the number of flushes per day and per week. (Put a pad and pencil on the tank top!) Assuming that this is the average consumption, how many litres of water are used per day, month, and year in your toilet(s)? Divide by the number of people in your family to find the per capita average daily use. When large amounts of water are used, the volume is generally stated in cubic metres (m^3) rather than litres (L). Take the total use over a year in litres and convert it to cubic metres. If you know the number of litres, divide by 1000 to convert to cubic metres.

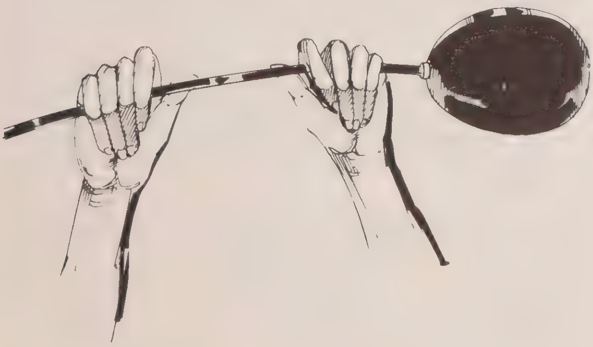
★ It really only requires about 10 L of water to flush the toilet. How many litres could you save per day, month, or year in your home by just reducing the volume of each flush? When you have determined the total amount of water used in your home for a year (p. 21 and table 4.5), determine the number of days of total use the above saving would represent.

★ Discuss with your family ways of reducing the number of flushes you make every day. Try them and keep records for the next week or two. If you and your family continued in this way, how much water would be saved in your home over the year by this conservation strategy *in addition* to that saved by reducing the volume of each flush?

★ Reduce the volume of water you use to 10 from 12 L. One way is by using a brick or two (or appropriate stones) of the kind that do not deteriorate in water. Be careful: these bricks must not prevent the devices inside the tank from operating.



★ A better way: Help your parents remove the ball-and-rod float mechanism in the toilet tank; then bend the rod so the float sits lower in the tank. Do the necessary calculations to find out where it should be for a 10 L flush. (*Note:* There is a tap under the tank that you can turn off while working on the float rod.)



Baths Versus Showers

★ At what point does the hygienic need to keep our bodies clean become a fetish or energy-consuming habit? Think about it.

★ Take a survey in your class and determine the *average* number of showers and/or baths *per person* per week in all the homes represented. (Do this so that the data from one individual home is not known by all the others.) Now, how does the situation in your home compare to the average? What situations would naturally lead to a large number of both baths and showers per person?

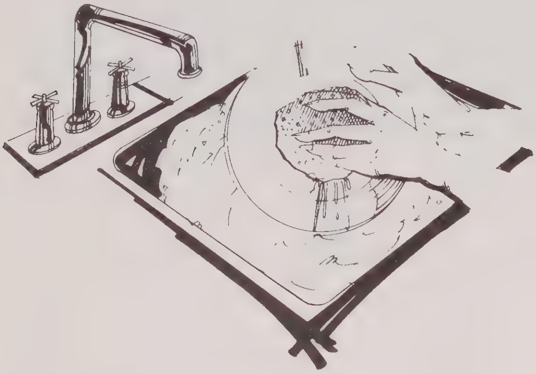
★ The next time you take a bath, measure the depth of water used in centimetres. When you take a shower, put the plug in and again measure the depth of water. What do your results tell you? Calculate the volume difference in litres. Is there any difference in the average temperature of water used? In which case does more energy from the water escape into the room and heat it up? Do you run an exhaust fan while bathing or showering? Should you do so?

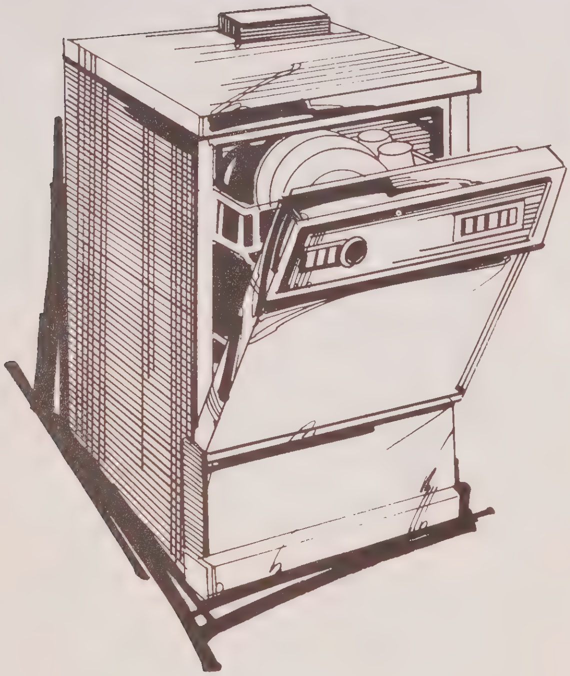
Now, let's move into the kitchen for a few activities.

Washing Dishes

One of the main reasons our per-capita energy consumption is increasing is the trend towards automatic dishwashers.

The largest amount of energy consumed by "washing machines", like dishwashers, lies in the hot water they use. Compare the amount of energy used by a dish-washing machine with the amount used in getting the same job done by hand.





★ 1. Wash and rinse a load of dishes by hand. Record the volume and the temperature of the water used and the cold-water temperature. The amount of water is conveniently measured by marking the level of water in the sink and then filling the sink to the same level – either with a measuring jug, a bottle, or a pail of known volume – *or* by assuming a rectangular volume and calculating.

2. Wash a load of dishes in a dishwasher, catching the water in the sink as it comes out. Be careful; it may be more than one full sink of water: be ready to pull the plug. Determine the volume and temperature of the water as before.

Refer to the activities on pp. 30-2 in Section 4 to calculate the *energy* used to heat the water in each of the above situations.

Now, considering that one day's dishes for a family of four can usually be washed in one machine load and that it probably requires three full sinks of water to do the job by hand, which method appears to consume more energy?

Note: Dishwashers often have a heating element to dry the dishes. Unless you're in a hurry, the dishes will dry just as well in the air, if you open the door slightly! This will save 0.4 to 1.0 kW•h (about 1.6 to 3.6 MJ) per load. (See the related activities on electrical energy in Part 3 of this resource guide.)

If you have a dishwasher, make a list of energy-conservation "do's" and "dont's" for using it.

★ Determine or estimate the volume of water your family uses each day to wash dishes and what percentage of it is hot water. Keep a record of both the cold-water temperature and the hot-water washing mixture for later calculations. Extend your calculations to weekly, monthly, and yearly averages.

Washing Clothes

★ Although a little more difficult, another person or group might like to do a similar exercise to that above on a load of laundry washed in a clothes washer. Again, measure the volume of water released and be ready to pull the plug in the sink. Since water at different temperatures may be used, some approximations will have to be made.

> **Some Hints on Using the Washing Machine**
> *Full loads.* Your washer – automatic or manual – should be used only when you have a full load.
>
> *Overloads.* Overloading reduces the cleaning action of a washer, resulting in more abrasions, more lint, and more wrinkles. In fact, too large a load can waste energy by forcing you to do some items over again.
>
> *Save hot water.* The biggest cost item in washing clothes is the hot water. The more you can do with cold and warm wash cycles, the more energy you save. Permanent-press items need only warm water. Cool or cold water is fine for washable woolens. Lightly soiled items can often be cleaned without hot water.
>
> *Water level selector.* If your automatic washer has a water level selector, choose the correct setting for the size of the load.
>
> *Cold water wash.* Many people now use nothing but cold water washes and find their clothes come out just as clean.
>
> From *100 Ways to Save Energy and Money in the Home*, p. 109.

★ Develop and extend the above list and post it beside your washing machine.

★ If you use a laundromat or laundry, see if you can determine the percentage of the cost that goes towards the energy used. Are there instructions or advice posted to encourage energy conservation? If not, ask the manager to consider the idea.

Water-Using Appliances

★ Determine, by actual measurement or by using manufacturers' figures, the number of litres per load used when employing a dishwasher, clothes washer, garbage disposal unit, and so on. Using the average values given in table 4.6, estimate the number of litres per week, month, and year for your family. For each device not covered in earlier activities, devise a list of recommendations to cut down on the volume of water used. If hot water is involved, can cooler or cold water be substituted? Post each list beside the appropriate device in your home. Could you do without the device completely?

Table 4.6

Water Appliances	Average Consumption of Water
Dishwasher	55–70 L/load
Clothes washer	150 L/load
Electric kettle	2 L to fill
Garbage disposal	12 L/use

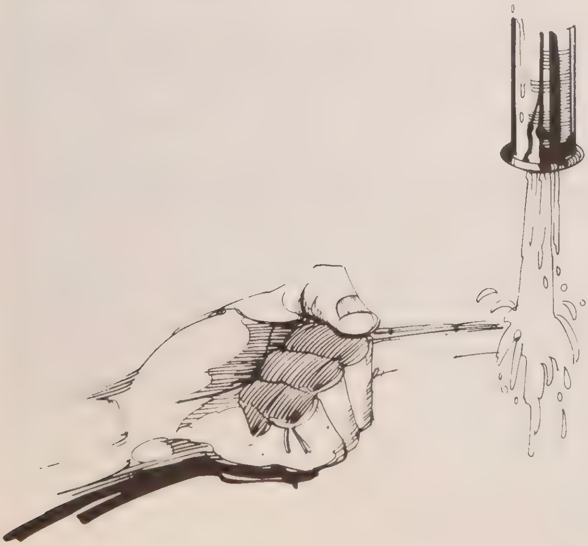
★ Take a survey of your class to find out what water-using devices exist, and calculate the percentage of homes having each one. Determine what the situation was one year ago, two years ago, etc. Draw conclusions.

A Special Case?

★ A certain amount of water vapour in the air (humidity) makes for comfortable living. How does it get into the air in your home? List as many ways as possible. What factors influence the humidity? What are the devices used in your home (school) to control the humidity and how do they work? What type of energy do they use? Do they operate only when needed? What time of year is water added to or removed from the air in your home? Why?

The Use of Stationary Versus Running Water

Before doing the next five activities, discuss with your class or group what you think the answers will be and why. Then try the activities in your home.



★ List the situations where you let the tap "run" so that the water reaches the desired temperature (either hot or cold). In each case, justify your decision and/or suggest an alternative procedure. Do the students in your school jam the water fountains so that they run continuously?

★ At the sink, wash your hands under running water and time the job in seconds. The next time, use the plug and run the tap(s) for the same length of time. Is this volume of water more or less than is needed? Determine the volume needed for each method and the difference in litres. Do you wash, *then* rinse, or do you do both together? What do you feel is the best method of washing your hands both from the point of view of hygiene *and* of energy conservation? Do you ever wash your hands when it is not really necessary?

★ Assuming that the dishes are washed and rinsed in the sink in your home, try the same experiment with them as you did with washing your hands above.

★ Where, how, and how often do you wash your hair? Suggest different ways and estimate the water used in each case. What are your recommendations? What method do you use?

★ Where, how, and how often do you wash your dog (or pet)? Suggest alternatives and recommend one with reasons.

Conclusion

★ From the results of these activities, discuss with your family and/or class ways of reducing water consumption in the areas concerned. If the recommendations you propose were followed, estimate the volume of water that could be saved over a month or year in your home. Are there other activities in which you use an excessive amount of water because it is left running? (How do you brush your teeth?)

Now, let's take a look at some special uses of water. They can easily get "out of hand" and consume large quantities of water and energy.

Excessive Use of Water? – Lawns, Cars, Pools . . .

> *Watering Can(ned)*
>
> *Car washing, lawn sprinkling hours laid down for residents of Gatineau*
>
> A bylaw standardizing restrictions on water consumption throughout the town of Gatineau was unanimously adopted by council Monday.
>
> The bylaw was narrowly defeated by council two weeks ago.
>
> The new bylaw makes it an offence to water lawns, wash cars or fill swimming pools between 3 p.m. and 11 p.m. seven days a week, between May 15 and Sept. 15 of each year.
>
> Offenders are subject to fines of between $10 and $300, or a jail term of up to four days if the fines are not paid. . . .
>
> The bylaw was first proposed by Gatineau's administrative committee last month, following complaints by area residents of excessively low water pressure during peak consumption hours.
>
> From *The Ottawa Citizen*, July 6, 1976, p.4.

★ Discuss this newspaper article in your class or group and then comment on the following ideas:

1. Before water, or energy, is conserved by large numbers of people, laws will have to be established so that people who break the laws can be punished.

2. Why does the bylaw in the article only refer to a certain time of day and a certain time of year?

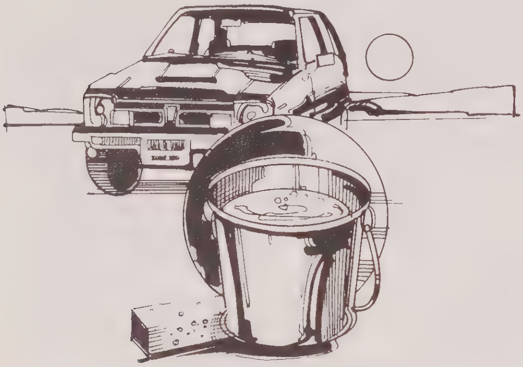
3. Do you think the fines or jail term are too harsh or too weak? Why?

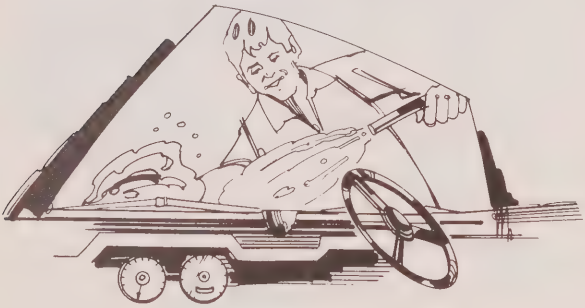
4. What is implied about the effect of "complaining" to your government representatives ?

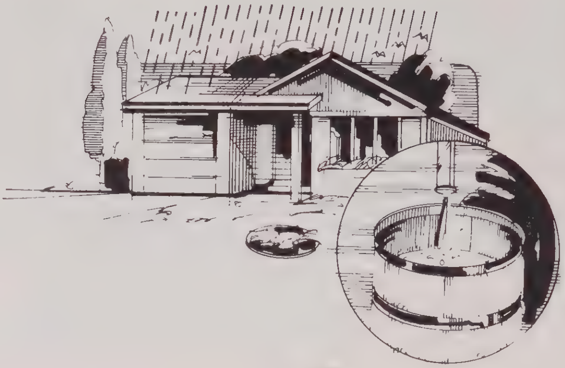
The Car

★ Compare the relative amounts of water and/or energy being used to wash the family car by the methods shown below. Why and when is a car washed? By what method and how often is your family's car(s) washed? Produce monthly and yearly estimates of the water volume used. Draw conclusions.

Note: Why does washing the car correctly also save the car?







The Lawn

★ A convenient unit to determine is the number of litres per hour you use to water your lawn. This will allow you to calculate the total water used per year by estimating the number of hours per day the system is working and the number of days per year you water. Use one of the following methods to determine the hourly amount:

1. While you are watering the lawn, and no other water is being used, read your water meter when you start watering and after one hour of watering.

2. If you use a sprinkler or hose, let it run in a pail for one minute, then measure the volume and multiply by sixty.

3. Put a pan on the grass under the sprinkler and measure the time required for 1 or 2 cm to be collected. Measure the volume of water collected and the pan's area. Divide the pan's area into the total area of the lawn and multiply this figure by the volume of water in the pan. Then convert to litres per hour (L/h).

★ Calculate the litres per year (L/a) of water that you put on your lawn to help it grow. Convert your answer to cubic metres per year (m^3/a).

★ We fertilize and water the lawn to make it grow; then we *cut* it! All these activities require energy! Discuss this idea and develop a list of the various types of energy converted in order to maintain a lawn. Using data given in other units, you might try to estimate the number of joules per year per square metre required.

★ Answer the following questions:

1. Under what conditions (when and for how long) should a lawn be watered?

2. What happens to the rain water, melting snow, and so on that hits the roof of your house each year? Are you able to collect it?

3. What is a cistern?

The Pool

★ Calculate (estimate) the volume of water used per year. What happens to the water? Is it used when the pool is emptied?

Note: If your pool is heated, this is *quite another matter.* See Section 4 for appropriate calculations.

The Ice Rink

★ Do you have an ice rink in the backyard in the winter?

Estimate the volume of water used to produce and maintain it for the season:

1. *initial production* – volume *(l* x *w* x *h)* in litres;

2. *maintenance* – number of hours of watering times the number of litres per hour used (see the activities in "The Lawn" above).

Although this water is not "wasted", it does represent energy used. Explain why this is so.

We complete this section by looking into a few activities where there is a true need for water.

Growing Food and Flowers

★ Estimate the number of cubic metres per year you use to grow things *other than* the lawn. Present arguments as to why (or why not) this is a good use of water. See if you can determine the percentage of total water use in Ontario that goes to the agricultural sector of our society.

Water Used for Drinking and Cooking

You might not have expected to find this set of activities last in the section. What does this imply about the amount we use for these purposes? If you think about it in light of Section 1, is this not the *major need* we have for water? Yet we use the smallest amount of water to fill this need!

★ Answer the following questions:

1. What average volume of water does the body actually require every day?

2. What is the major use of the water in the kitchen associated with cooking?

3. Describe the way hot water for tea or coffee is produced in your home. How should it be done in order to save both water and the energy used to heat it?

4. List some foods that are prepared with water and in which water is the major component.

5. List some foods that use water in their preparation (i.e., heating), but then have the water removed and discarded with little decrease in volume due to absorption or boiling away.

6. In what cooking situations is water changed to steam and used in this form? Is the water retained in the food?

7. List some of the common ways of getting a drink of cold water. Considering these from an energy-conservation point of view, which method is preferred?

Conclusion

★ If so little water is used for drinking and cooking, what attitudes and values have we fostered and developed to make our demands for water so high? (Look at the various groups of activities in this section in order to answer this question.) What *changes* in attitudes and values do you think will have to occur in our society before a major reduction in water use might come about?

The next section looks at how all the various water uses in the home, which were studied in this section, integrate to form a total pattern of water use.

4. Volume and Energy Accounting and Extensions

This section begins with activities that lead to the production of a flow chart for water use in your home. This is most important for the consideration of water-conservation decisions.

The energy associated with water use is developed with special emphasis on hot-water activities. These include the source energies used to heat the water.

The concluding activities extend these ideas into the community over a period of time, thus extending the systems view introduced earlier in Part 1.

Monitoring Home Water Use

Now that you have looked at the water flow through the individual components of your home (or school), let's look at the total water use in the building. Remember that this building is only a single component in the total water system.

★ Develop a flow chart for your home (or school) as in figure 4.5. It is best if the data used are those that you collected in earlier activities. Estimate figures where necessary and produce as complete a picture as possible. Figure 4.5 is an estimate for a family of two adults and two children.

Take into account *your* specific family and its use of water to get as realistic a picture as possible. Compare your flow chart with others produced in your group or class. Calculate the percentage of water used in each branch of the chart in relation to the total.

★ If you have a water meter, see table 4.4 and the associated activity. Take the total volume used during one week and divide by seven to convert to average litres per day (L/d). Work from the components you are most sure of from the activities you completed in the previous section. Compare your percentage figures to others in your group or class. Can you account for the differences?

The water in your house is used through the combined efforts of all the people living there. By using the above information, you can now calculate what the average person uses each day.

★ Develop a chart for your home *similar* to the one shown in figure 4.5. Remember to use the totals for the week, then divide by seven and *then* by the number of people in your family. The flow chart will now be in litres per capita per day and you *can* compare it to others developed in your class.

★ By using the results of others doing the same activity, develop an "average" usage chart for residential water use in litres per capita per day, as shown in table 4.7.

This chart will give you a rough idea of how the "average person" in your community uses water on "an average day". This will vary widely depending on the particular situation, but it might be interesting to look at the chart in light of the per-capita use in your own home.

★ Considering the charts above, indicate the general areas that could benefit from water-conservation practices in your home. Make one recommendation in each area selected.

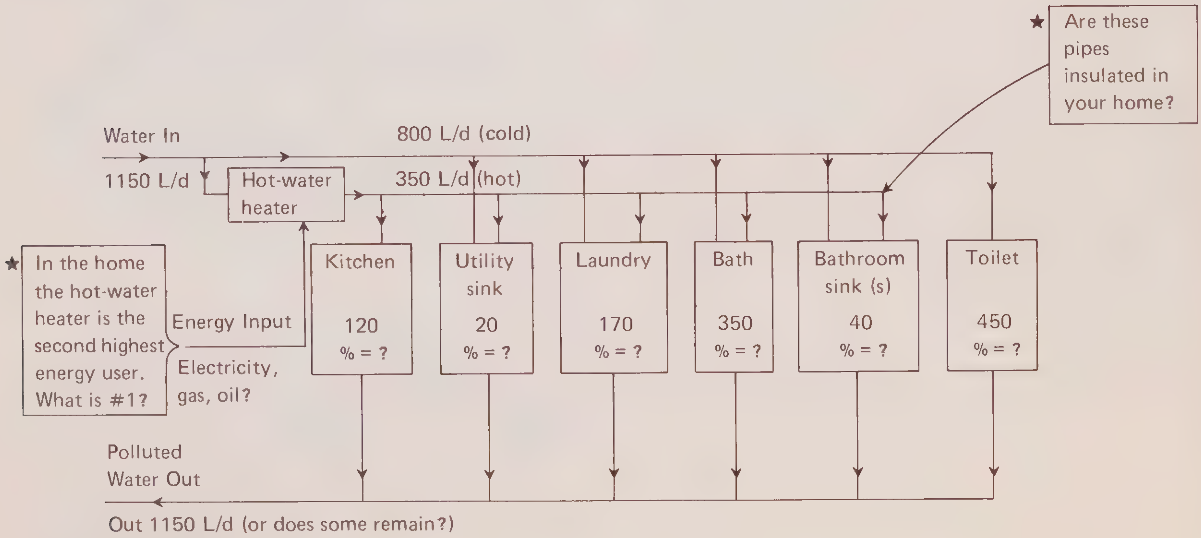
Table 4.7

Per Capita Residential Water Use (Average)

Types of Water Use	Litres Per Capita Per Day	Per Cent
Toilet flush		
Bathing (and shower)		
Kitchen		
etc.		
Totals		100%

Figure 4.5

Residential Water Flow Chart



★ Are these pipes insulated in your home?

★ In the home the hot-water heater is the second highest energy user. What is #1?

Using Your Water and Sewage Bills

If your water is supplied by a utility, it is possible that the service is paid for by bills sent to your home every few months. If this is the case, using the bills, as outlined in the next activities, will provide you with accurate data on water use.

★ If previous water bills are available from your parents, convert the amounts of water used to litres and draw a bar graph of the consumption over the time span covered by the bills. Graph also the cost of the water and sewage. How are the above costs determined? Account for any changes in observed usage and/or costs. What is the cost of 1 kL (or 1 m^3) of water? (Do the arithmetic!)

★ Answer the following questions using the bills shown here (or better yet, a set of your own):

1. How many days passed between the first and third bills?

2. What is the total water used *in the above time:*

a) in hundreds of cubic feet

b) in kilolitres (kL) or cubic metres (m^3)

3. What was the average number of litres per day used in the household?

4. If this represents the water used by five people, what was the average number of litres per capita per day?

5. What is the most likely explanation for the high consumption recorded in the August bill?

6. On each bill, calculate the water charge for 1 kL or 1 m^3 of water?

7. On each bill, calculate the percentage of the water charge made up by the sewage charge.

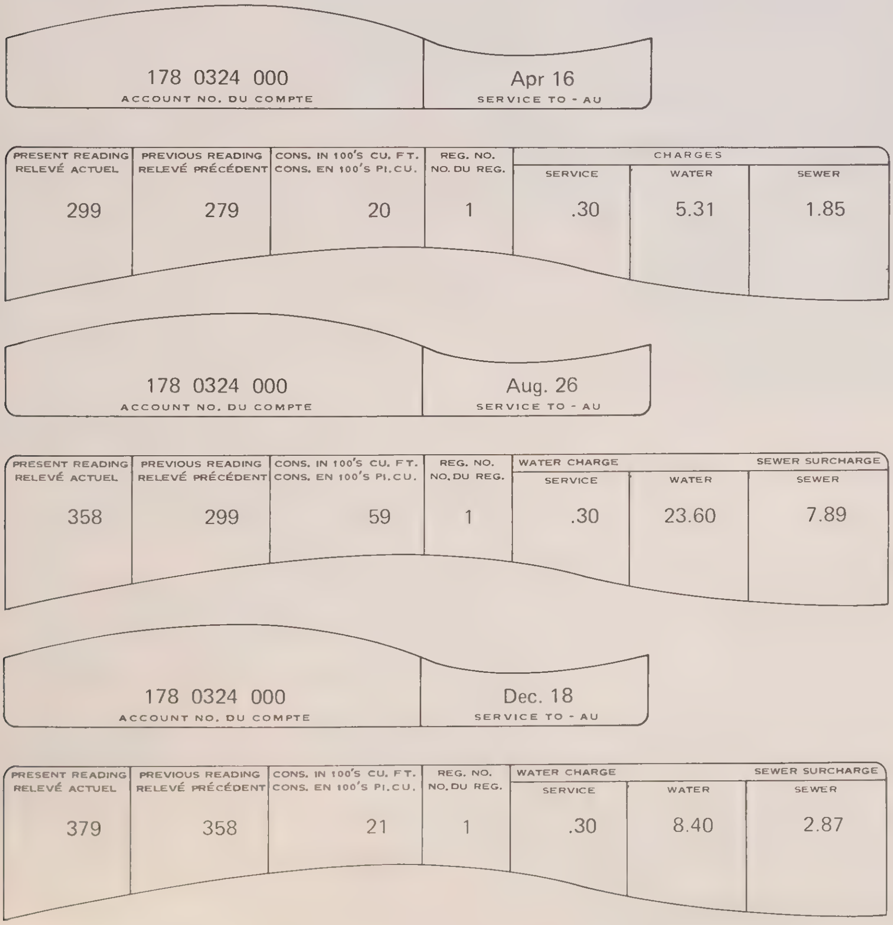
8. Draw conclusions from your answers to (6) and (7) above.

Using Water Converts Energy

For you to have the water you use, it must be collected (from wells, rivers, and so on), purified, and then distributed to your home. Some of it is then heated using electricity, gas, or oil. After use, the sewage, which is mostly water, is collected, purified, and discharged. Who does all this work for you? How much energy is used? These are complicated questions, and you will only be able to get a rough "feeling" for the true situation by completing the activities on the next page.

Figure 4.6

An Example Set of Water/Sewage Bills



ACCOUNT NO. DU COMPTE	SERVICE TO - AU
178 0324 000	Apr 16

PRESENT READING RELEVÉ ACTUEL	PREVIOUS READING RELEVÉ PRÉCÉDENT	CONS. IN 100'S CU. FT. CONS. EN 100'S PI.CU.	REG. NO. NO. DU REG.	CHARGES		
				SERVICE	WATER	SEWER
299	279	20	1	.30	5.31	1.85

ACCOUNT NO. DU COMPTE	SERVICE TO - AU
178 0324 000	Aug. 26

PRESENT READING RELEVÉ ACTUEL	PREVIOUS READING RELEVÉ PRÉCÉDENT	CONS. IN 100'S CU. FT. CONS. EN 100'S PI.CU.	REG. NO. NO. DU REG.	WATER CHARGE		SEWER SURCHARGE
				SERVICE	WATER	SEWER
358	299	59	1	.30	23.60	7.89

ACCOUNT NO. DU COMPTE	SERVICE TO - AU
178 0324 000	Dec. 18

PRESENT READING RELEVÉ ACTUEL	PREVIOUS READING RELEVÉ PRÉCÉDENT	CONS. IN 100'S CU. FT. CONS. EN 100'S PI.CU.	REG. NO. NO. DU REG.	WATER CHARGE		SEWER SURCHARGE
				SERVICE	WATER	SEWER
379	358	21	1	.30	8.40	2.87

Source: Ottawa Hydro

Lifting Water (Try It. It's Heavy!)

★ There is a lot of hidden energy put into all the water you use. The largest percentage is in lifting the water from its source to the elevation of your tap (actually higher – why?).

To lift 1 L of water 1 m requires about 10 J of energy. Assume that your home is 30 m above the source of water and uses 1000 L/d. Calculate the energy used to lift the water in kilojoules and megajoules.

★ Use the type of calculation above to estimate the total number of kilojoules or megajoules your family uses on a daily basis. You have determined the total litres per day in the activity given in Figure 4.5; now all you need is an estimate of the elevation of your house above the source of the water supply (lake, river, water table) for the system you are connected to. Don't be afraid to estimate!

★ Try carrying two pails of water up a flight of stairs. Determine the number of litres, the height in metres, and the energy required to lift the water up the flight of stairs (besides the energy you expend in getting yourself up the stairs). How many trips would you have to make to equal the energy converted in the previous calculation?

★ The actual energy required per litre to do the job is higher than the above. Suggest some reasons why this would be.

The instant *you turn on any tap, the water pressure built up for you is released and the water returns by gravity to the sewer. All the above energy has been converted. Has it been wasted? It depends on whether you* used *the water and on* how *you used it!*

Treating the Water and Resulting Sewage

★ Energy is also required to purify the water; operate and maintain the system; collect the sewage; and treat and discharge the sewage. For an approximate estimate of this add 100 J/L used to the totals calculated in the previous activities.

★ It is now possible for you to estimate the energy used in any of the cold-water activities carried out earlier, either in single components or in the total water used at a location on a daily, weekly, or yearly basis. Pick a couple of situations and try it (toilet flushing or lawn watering, for example). Calculate the energy per litre per day and the energy per litre per capita per day for the various flows of water in figure 4.5 "Residential Water Flow Chart" that you adapted to your own situation.

Energy in Hot Water

Now, let's heat some of the water and see what energy is required.

★ Let the cold- and hot-water taps run for a few minutes (when you are using the water!), and measure the temperature of each in degrees Celsius. To change the temperature of 1 L of water 1°C requires 4.2 kJ. Find the number of kilojoules necessary to heat 1 L of the hot water used in *your* home. (For example, 1 L from 5°C to 70°C requires about 273 kJ or 0.273 MJ

$$(1\ \text{L} \times 65^{\circ}\text{C} \times 4.2\ \frac{\text{kJ}}{\text{L}\cdot{}^{\circ}\text{C}} = 273\ \text{kJ})$$

★ Estimate the number of litres per day of hot water *your family uses.* If a family of four (two adults and two children) on the average uses 360 L/d or 90 L/d (per capita), calculate the energy required to heat the water each day for your family. What energy is required per week? Per year? (For example, 360 L/d x 0.273 MJ/L x 365 d/a = 35 872 MJ/a ≃ 36 GJ/a!)

Note: If you have trouble estimating the actual volume of hot water you use, assume that you heat 30% of your cold water. A short way to calculate the energy required to heat any volume of water is given by:

$$E = 0.0042 \times V \times \Delta T$$

(The 0.0042 means 0.0042 MJ/L• °C)

E = Energy required in megajoules (MJ)

V = Volume of water in litres (L)

ΔT = Change in temperature of the water (difference between the hot and the cold water)

Try this method in your calculations in the two previous activities. Use it any time you want to know the energy used to heat water. For example, see the activities on showers and baths, washing dishes, and washing clothes, in Section 3.

★ Refer to the activities concerning energy in using cold water and treating sewage above. Compare the energy required to use 1 L of cold water in your home to the additional energy you add if you heat it. What do you conclude?

★ Complete the following based on the "average day" (refer to the chart you produced based on figure 4.5).

1. a) 1 L of cold water used in my home represents ________ kJ of energy converted.

b) 1 L of this water *heated* in my home represents ________ kJ of additional energy converted.

Note: For 1000 L of water, the number would remain the same, but the unit would change to MJ.

2. Our home uses ______ L/d in total water representing
______ MJ and ______ % of this or ______ L/d is heated from
______ °C to ______ °C. This represents an additional
______ MJ, so the total energy converted on an "average day" is
______ MJ or ______ MJ per person. Over a year, this would
represent ______ GJ in total or ______ GJ per capita.

3. Determine the group or class average for the per capita energy calculations. Now, is this the complete picture?

Working Back to the Source

Your hot-water tank is probably heated by electricity, natural gas, or #2 heating oil. Assume that on the average:

1 gallon of heating oil will heat approximately 110 gallons or 500 L of water

1 cubic foot of natural gas will heat approximately 1.2 gallons or 5.5 L of water.

1 kW•h of electrical energy will heat approximately 4 gallons or 18 L of water.

★ Convert the litres per day of hot water you use into the equivalent amount of source fuels. Do it for a year.

To be a *little* more accurate, apply the following factors to your answers to the previous activity, since that activity used only an average temperature change. See the activities on p. 30 and below for *your* temperature change, volume estimates, and calculations required.

1 gallon of #2 heating oil supplies approximately 177 MJ.

1 cubic foot of natural gas supplies approximately 1.116 MJ.

1 kW•h of electricity supplies approximately 3.601 MJ.

Figures in this chart assume 100% conversion of energy.

But this is still not accurate! When natural gas or oil is burned, "waste" heat is produced since the combustion and resulting energy transfer are not 100% efficient. Electric heating is almost 100% efficient, but the production and transmission is not! It is only about 32% efficient. This means that even more energy is converted than that calculated in the above activity!

Water Heating Efficiency

★ Figure 4.7 (a), (b), and (c) show three ways in which water is heated in the home.

1. How much energy is converted into useful heat in figure (a)? In figure (b)? In figure (c)?

2. How much more natural gas is used in figure (a) compared to figure (b)?

3. How much energy is wasted in each method? What happens to this energy?

4. In which method is energy used most efficiently? Explain your answer. Based on your work, do you think the "all-electric" home conserves or wastes energy?

5. According to electric power companies, there is less air pollution and better fuel economy from a central power station than from many separate homes using fossil fuels. Do you agree or disagree? Do most power plants control air pollution well, and do they reuse waste heat?

6. Should an electrically heated hot-water tank be converted to an oil-heated one if the space-heating system in the house is oil? Discuss the "pros" and "cons".

To include the efficiency conversion, your earlier results *for source fuel calculations must be increased* by an appropriate factor if:

an oil burner is 65% efficient; multiply energy by 1.53;

a natural gas burner is 70% efficient, multiply energy by 1.42*;

electricity is 100% efficient; multiply energy by 1.00**.

★ If your water is heated by oil or natural gas, use the above and your figures calculated earlier, to determine the total amount of the source fuel used to heat the water in your home over one year.

The Cost of Heating Water

★ Determine the cost of the energy you use to heat water. Some values*** might be 3¢/kW•h, 50¢/gal. or 0.25¢/cubic foot. Convert your litres per day figure to energy per day and then to source-fuel units per day. Calculate the cost per day, then produce a yearly or monthly figure. What percentage of your home's total energy bill (gas, oil, or electricity) is used just to heat your water?

Now let's take a look at some of the earlier activities involving hot water and determine the energy involved. Use the energy equivalents developed in the chart on p. 30, related to an "average day" and in the section on "Working Back to the Source", even though they are low, or what you consider to be the most realistic conversion factor calculated in the above activities.

That Dripping Tap

★ Convert the litres per day or per month lost by the dripping tap on p. 20 to energy lost. If you wish, Use information from the activities on "Working Back to the Source" to convert to oil or gas equivalents, and the activity above to convert the energy to costs.

The Bath or Shower

★ Determine the energy you use to bathe and/or shower for a year:

1. Determine in litres the volume of water you use for a single bath or shower in the activities in "Baths Versus Showers" in Section 3 (p. 23).

2. Measure the temperature of the warm water and the temperature of the water form the cold-water tap, both in degrees Celsius, and subtract.

3. See the activities in "Energy in Hot Water" in Section 4 to calculate the energy required per bath or shower (p. 30).

4. Multiply the above energy by the estimated number of baths and/or showers you take in a year. You could extend this to include all your family and thus see what percentage the total energy used to heat water over a year is used for bathing.

The Kitchen Sink

★ Calculate the energy in a kitchen sink full of hot water used to do dishes. The calculations are the same as the ones used above for a bath.

Don't let hot water run down the drain in the winter. Why not? Let the bath water, dishwater, etc., cool before pulling the plug. When boiling a kettle of water, should you start with hot or cold water, or does it matter?

---

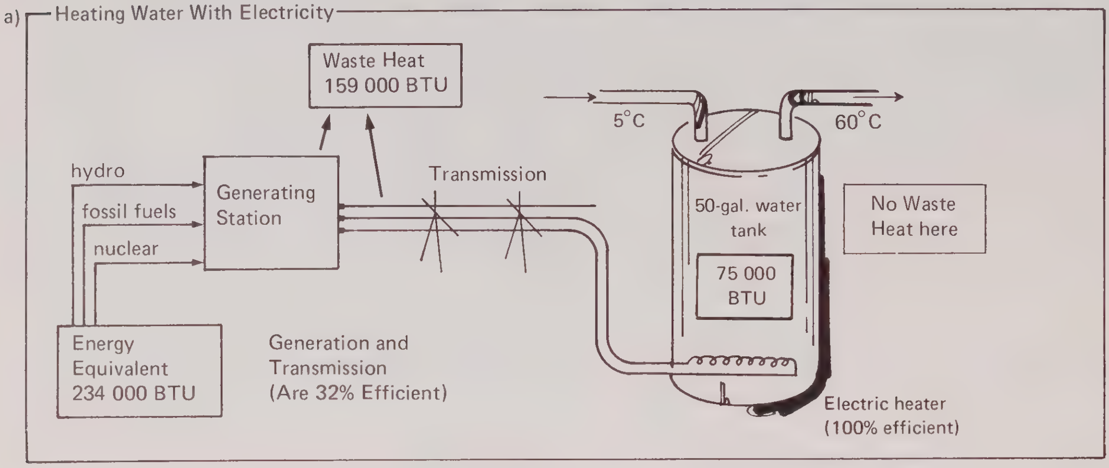
*This will be a direct cost to the home owner. What happens to "waste" heat? Is it really wasted?

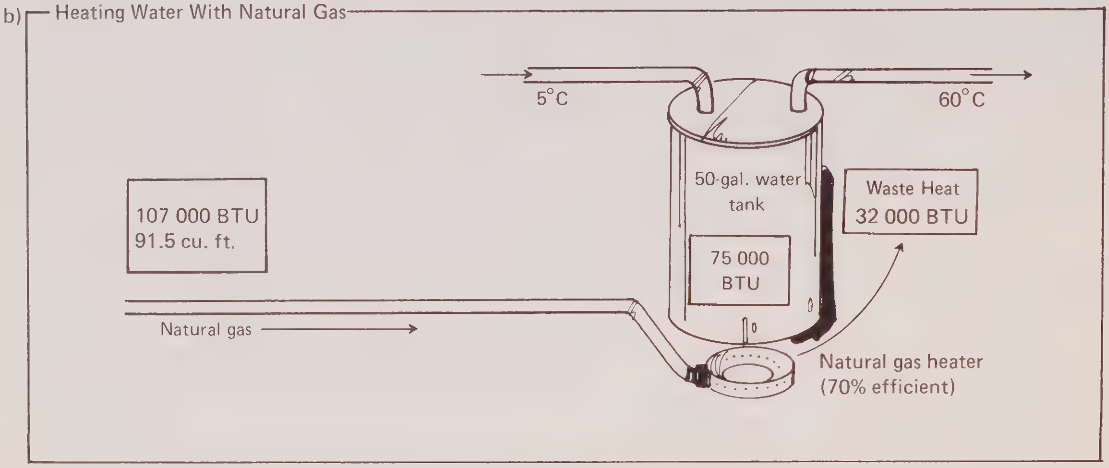
**On the electrical side, the waste heat is somewhat of an indirect cost, but is it used? For the direct cost calculation only, assume that 100% of electrical energy is converted to heat in the water. Do not multiply by 3.12.

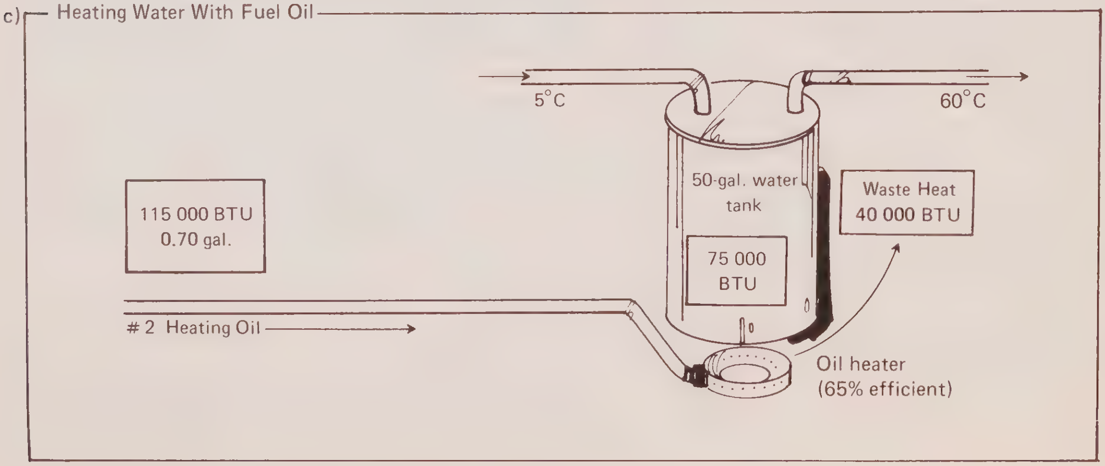
***Do *not* trust these; they are always going up! Use the current values if you can determine them.

Figure 4.7

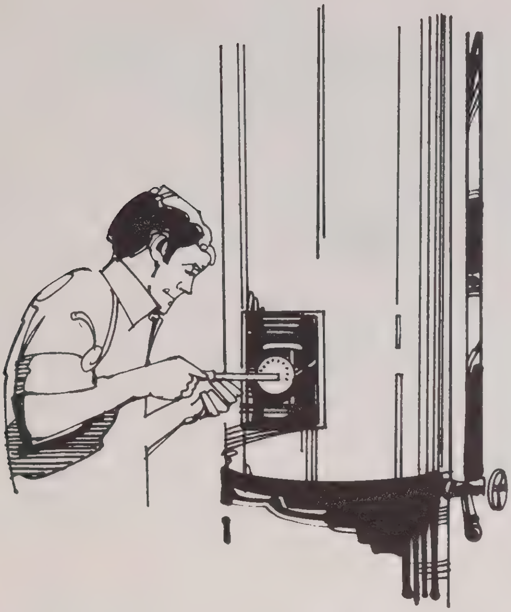
Efficiency of Water Heating


a) Heating Water With Electricity


b) Heating Water With Natural Gas


c) Heating Water With Fuel Oil

Adapted from Pollution Control Education Centre, *Protecting Our Water Supplies: Priority One Environment* (Union, N.J.: Union School Board, n.d.).



The Water Heater

There is a temperature adjustment device on your hot-water heater. It should be set as low as possible. Maximum temperatures required are approximately: 60°C for a dishwasher; 49°C for dishes; and 43°C for washing clothes.

★ Reduce the temperature setting to the minimum required by your family's needs. Contact your hydro, gas, or oil company to find out how to do this before you start.

★ From the list you made of activities that require hot water, suggest methods to reduce or omit entirely the volume of hot water used. Discuss this with your class or group as well as with your family. Make the decision to try some of the ideas!

Your home is but a single component in the residential sector of the water-supply system. The next few activities look briefly at other "components" and other "sectors" of the system.

Table 4.8

Estimated Water Consumption at Different Types of Establishments

Type of establishment	(gpcd)*	Type of establishment	(gpcd)*
Dwelling units, residential		Institutions	
Private dwellings on individual wells or metered supply	50 – 75	Average type	75 – 125
Apartment houses on individual wells	75 – 100	Hospitals	150 – 250
Private dwellings on public water supply, unmetered	100 – 200	Schools	
Apartment houses on public water supply, unmetered	100 – 200	Day, with no cafeteria, gymnasium, or showers	15
Subdivision dwelling on individual well, in metered supply, per bedroom	150	Day, with cafeteria or lunch room, no gymnasiums or showers	10 – 20
Subdivision dwelling on public water supply, unmetered, per bedroom	200	Day, with cafeteria and showers	15 – 25
Dwelling units, treatment		Boarding	75 – 100
Motels	50 – 100	Theatres	
Boarding houses	50	Indoor, per seat, two showings per day	3
Lodging houses and tourist homes	40	Outdoor, including food stand, per car (3⅓ persons)	3 – 5
Motels, without kitchens, per unit	100 – 150	Automobile service stations	
Camps		Per vehicle served	10
Pioneer type	25	Per set of pumps	500
Children's, central toilet and bath	40 – 50	Stores	
Bay, no meals	15	First 25 ft frontage	450
Luxury, private bath	100 – 150	Each additional 25 ft frontage	400
Trailer with private toilet and bath, per unit (2½ persons)	125 – 150	Country clubs	
Restaurants (including toilet)		Resident type	100
Average	7 – 10	Transient type, serving meals	17 – 25
Kitchen wastes only	2½ – 3	Offices	10 – 15
Short order	4	Factories, sanitary wastes, per shift	15 – 35
Short order, paper service	1 – 2	Self-service laundry, per machine	250 – 500
Bars and cocktail lounges	2	Bowling alleys, per alley	200
Average type, per seat	35	Swimming pools and beaches, toilet and shower	10 – 15
Average type, 24 h, per seat	50	Picnic parks, with flush toilets	5 – 10
Tavern, per seat	20	Fairgrounds (based on daily attendance)	1
Service area, per counter seat (toll road)	350	Assembly halls, per seat	2
Service area, per table seat (toll road)	150	Airport, per passenger	3 – 5
Add 125 gallons per trailer space for lawn sprinkling, car washing, leakage, etc			

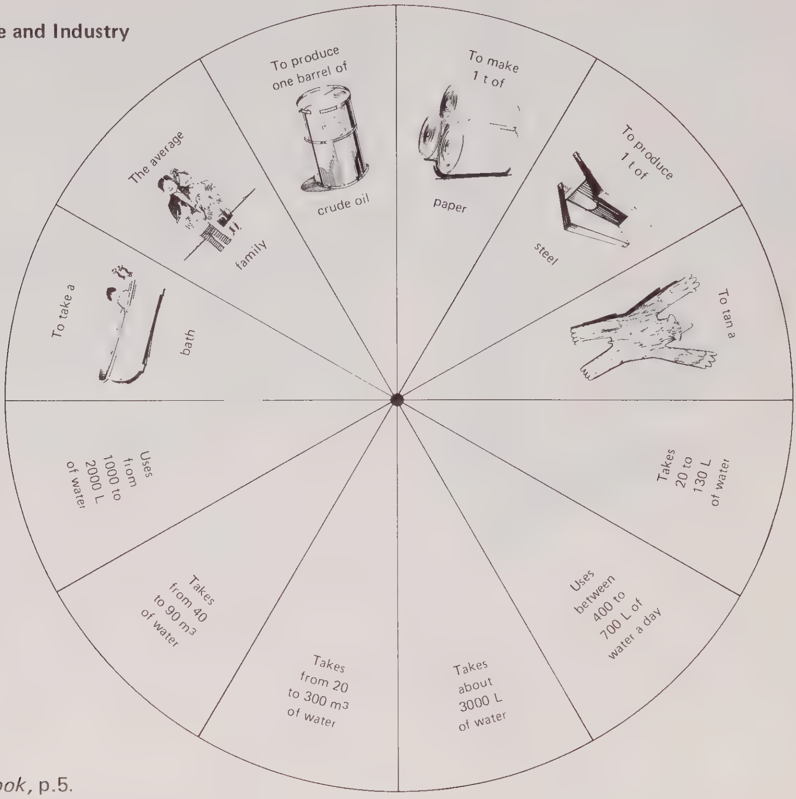
Note: Water under pressure, flush toilets, and wash basins are assumed provided unless otherwise indicated. These figures are offered as a guide; they should not be used blindly. Add for any continuous flows and industrial usages. Figures are flows per capita per day, unless otherwise stated.

Source: R. G. Bond and C. P. Straub, eds., in *CRC Handbook of Environmental Control* (Cleveland: Chemical Rubber Company, 1973). Reprinted with the permission of CRC Press, Inc.

* Students should convert these water consumption rates from imperial to metric units.

Figure 4.8

Use of Water in Home and Industry


To produce one barrel of crude oil
To make 1 t of paper
To produce 1 t of steel
To tan a
Takes 20 to 130 L of water
Uses between 400 to 700 L of water a day
Takes about 3000 L of water
Takes from 20 to 300 m3 of water
Takes from 40 to 90 m3 of water
Uses from 1000 to 2000 L of water
To take a bath
The average family

Source: *My Water Book*, p.5.

Water Use in Various Establishments

★ Do a little library research to determine the quantities of water used by small businesses, various types of industry, government, and so on. Refer to table 4.8 (p. 33) for some examples. Percentages should be identified, if possible. What are some extra-large consumers? (Write letters to institutions you think might help in the drive for water conservation.)

★ 1. Compare the appropriate residential values in this table, after converting to litres, to the value you calculated in the first activity in this section (p. 28).

2. Check the volume per day that your school uses with the values in the table (see the head custodian).

3. Check any other figures that you determined, or from the table, with a "real situation" – if you can.

Water Used by Industry

> Industries use much more water than people. Millions of litres of water are used each day to make things, to heat factories, and to wash products. Many industries use their water over and over again – and may have to cool it because it gets too hot, or heat it before using it again – or even clean it of any impurities.
>
> Some of the water used in factories is put into the products they make – products like face cream, soup, canned food, etc. When these products are shipped to the stores, the water goes with them. Then people buy the products and use them, and, through the body processes, the water is released and again put back into circulation.

From *My Water Book*, p. 5.

★ Use figure 4.8 to present some interesting ways of saving water and thus conserving energy.

★ As you think about it, your community water system interconnects with many other energy-conversion systems (e.g., electricity for water pumps, gasoline for service trucks, etc.), so that saving water indirectly saves energy in these other systems. Develop this idea by showing how the water system links up with a few other energy-conversion systems. Discuss your ideas with others: focus on those most directly related to the rate of water consumption.

The last few activities will show you what happens when all the components in the various sectors are added together and the result extended over time.

Our Demands Are Increasing

★ Have one student contact your city, town, or village government to obtain the gross figures for the amount of water used during each of the last several years. Construct a graph using the results.

1. Calculate the average from the data collected on a monthly and yearly basis.

2. Determine the average annual use of water per person using estimated population figures for the community.

3. Compute the daily per person water usage and compare it to what you found in the activity based on table 4.7 (p. 28). What would it include that was not included in your calculations?

4. What percentage of the total water use is accounted for by the residential sector (your home)?

Table 4.9 represents the average water consumption in gallons per capita per day for residential water use in the Borough of Etobicoke from 1955 to 1971.

★ Calculate the average yearly *increase* in litres per capita per day each year between 1955 and 1960. What are some reasons for the increase compared to the same calculation for 1965 to 1970? What assumption must be made in order to extend the figures to 1990?

Table 4.10 will help you understand the total effect of increased water consumption per capita as the population of Ontario increases.

★ Plot a graph of water use year by year. Multiply the population figures by the litres per capita per day from Table 4.9. If you can, add a new scale and plot the estimated water use in your community over the same time span. What are some factors that produce or affect the population(s) plotted? Discuss the implications of this graph with your group or class.

In a community, the residential sector along with other sectors, such as business and industry, combine together to produce a total demand on a water-supply–sewage-treatment system. The next section deals with what goes on in the portion of the system not immediately visible to the user. This is by far the largest portion.

Table 4.9

Water Consumption: Borough of Etobicoke

Year	Total water consumption (gallons per year)	Total (industrial, commercial and residential) water consumption (gallons per capita per day — gpcd)	Population of Borough of Etobicoke	Estimated residential water consumption (gallons per capita per day — gpcd)
1955	2 168 718 000	63.36	93 781	40
1956	2 723 588 000	76.24	99 673	47
1960	3 889 799 000	73.07	145 847	44
1961	4 334 165 000	77.58	153 067	45
1965	6 501 404 000	86.76	205 304	49
1966	7 319 325 000	92.94	215 764	50
1970	11 877 265 000	117.33	277 332	61
1971	12 303 679 000	119.76	281 476	60

(Adapted from Personal Communication: R. G. Hamilton, Superintendent, Water Accounting Department, Borough of Etobicoke)

Additional information on Estimated Average Water Consumption in Ontario for Industrial, Commercial and Residential use:

(i) *Municipal Daily Water Consumption* (Industrial, Commercial and Residential uses) per capita (Ontario average: 1976)
approximately *100* gallons

(ii) *Residential Only Daily Water Consumption* per capita (Ontario average: 1976)
approximately *50* gallons

(Information provided by Water Resources Branch, Ontario Statistical Centre)

Table 4.10

Ontario Population Estimates

Year	Total Population	Toronto Population	Your Community
1965	6 961 000	1 881 000	–
1970	7 703 000	2 086 000	–
1975	8 331 000	2 887 000	–
1980*	9 027 000	3 127 000	–
1985*	9 747 000	3 340 000	–
1990*	10 433 000	3 530 000	–

*Estimated

Sources: 1. Ontario population estimates from
(i) Statistics Canada, Catalogue #91-201, *Estimated Populations of Canada and the Provinces, 1972-2001* (Ottawa: Statistics Canada, 1976);
(ii) Statistics Canada, Catalogue #91-514, *Population Projections for Canada and the Provinces* (Ottawa: Statistics Canada, 1974).

2. Toronto population estimates from Statistics Canada, Catalogue #92-702, *Population – Historical* (Ottawa: Statistics Canada, 1971).

5. Man's Intervention in the Water Cycle

Introduction

Water is not really used up, just used. After use, it is returned to the environment. The methods by which the water is extracted, used, and returned are all energy-converting.

This section's activities deal with the typical stages in a water-supply/purification system and the associated sewage-treatment system. These two sub-systems are then expanded to a single, more comprehensive system which is itself a sub-system of the hydrologic cycle.

The Hydrologic Cycle

> At all times the water is being exchanged between the surface of the earth and the atmosphere. This exchange is accomplished by the heat of the sun and the pull of gravity.
>
> Wherever water is exposed to the atmosphere, the sun's energy causes it to evaporate and rise as a water vapour to form clouds. Moving with the air currents, the clouds collide and join together, or rise over a land mass until they cool when the vapour transforms into water droplets which fall as rain or snow.
>
> Three essential stages occur in this process: Evaporation – the turning of moisture into vapour; Transpiration – the giving off of moisture by plants; and Precipitation – the return of moisture from the atmosphere. Let's look at each stage in a little more detail.
>
> *Evaporation:* Although moisture will evaporate from any surface exposed to the atmosphere, the largest single source of evaporated moisture in the world is the huge area comprising the oceans. Acting like a vast heat engine, the sun warms the atmosphere which causes the moisture to change into a vapour. On the land, this same process takes place over all the rivers and lakes, and even over the soil itself where water is drawn to the surface of the earth and evaporated off. More water vapour is given off by plants and trees as they breathe – but that process is a little different and is the second stage of the hydrologic process.
>
> *Transpiration:* All plant forms give up moisture through their leaves. Trees, because of their huge size by comparison with other plant forms, evaporate tremendous amounts of water. In trees, water is taken from the soil by the roots, moves up the trunk as sap, and emerges from the plant through thousands of small holes on the underside of every leaf. It is estimated that a hectare of apple trees may transpire as much as 1400 t of water in a season. On a hot day, a good-sized apple tree may lose more than 4 L of water a minute.
>
> *Precipitation:* The amount of water vapour which the air can carry without loss by condensation depends on the air temperature. The higher the temperature the more vapour the air can carry. When moist air cools sufficiently, some vapour changes to liquid forming droplets which fall by gravity. Snow forms in a similar process, but the temperature is so low that the water freezes when the vapour condenses. The cooling of water vapour in the atmosphere comes about in two ways: when winds blow the clouds towards hills over which they are forced to climb into colder air; or when a mass of warm, moist air meets a mass of cold air.
>
> Water that falls to the surface of the earth is either absorbed by the oceans, lakes and rivers, or soaks into the ground through the soil. Once in the ground, the water follows the layer of soil by flowing between the particles of soil or sand or gravel until it reaches a point where the strata becomes exposed by steeply falling hill sides. There it will emerge from the ground to form springs which feed the streams and rivers which eventually lead back to the sea. Once having emerged from the ground, the water is once again exposed to the warm atmosphere and begins to evaporate – thus completing the hydrologic cycle.
>
> From *The Water Story*, p. 6.

★ 1. Develop a flow chart showing the water cycle in nature. The result should show that the sun is the principal driving energy with gravity playing the second major role.

2. With regard to human activities such as pollution, what problems are arising that are tending to upset the natural water cycle?

3. Is water a limited or unlimited resource? Where does the water you use really come from?

In many parts of the world, including Canada, global weather changes are becoming apparent. What are these, and how will they affect the cycle, especially in Canada? What cause or causes are given for these global changes?

Man Taps Into the Water Cycle

> Rivers run through valleys; lakes lie in bottom land; houses are built on the ground above the water. If, then, the water has been drawn from its source and prepared for domestic use, it must be somehow forced up the slopes to where it is needed. Somehow, having been carefully treated and made pure, it must be sent through the transmission mains that thread their way throughout the community.
>
> A carefully engineered network of distribution pipes lies buried beneath the roads and streets of most municipalities.
>
> Like the arteries and veins that carry blood through the body, the water mains that leave the treatment plant are the largest of the system, and branch off wherever necessary into smaller, and smaller, and yet smaller pipes at the extreme limits of the system. Stubbing off from these mains, wherever a service connection is required, pipes – often no thicker than your thumb – carry the essential water to the properties concerned.
>
> Forcing the water through these kilometres of pipes, always maintaining a constant positive pressure, is a battery of pumps in the high-lift pumping station. . . .
>
> So that the pressure of water available at the taps of a community might be uniformly equal, most systems have reservoirs or elevated storage tanks on heights of land to which the water is first pumped. A return pipe system then services the dwellings. By the time the tap in your house is turned on, the water you receive will have travelled a long way and have passed through many stages of treatment and supply. Because of the work done by the Ministry of the Environment and the water authority in your community, that water will be safe for you to do with as you will.
>
> Adapted from *The Water Story*, p. 6.

Figure 4.9

The Hydrologic Cycle

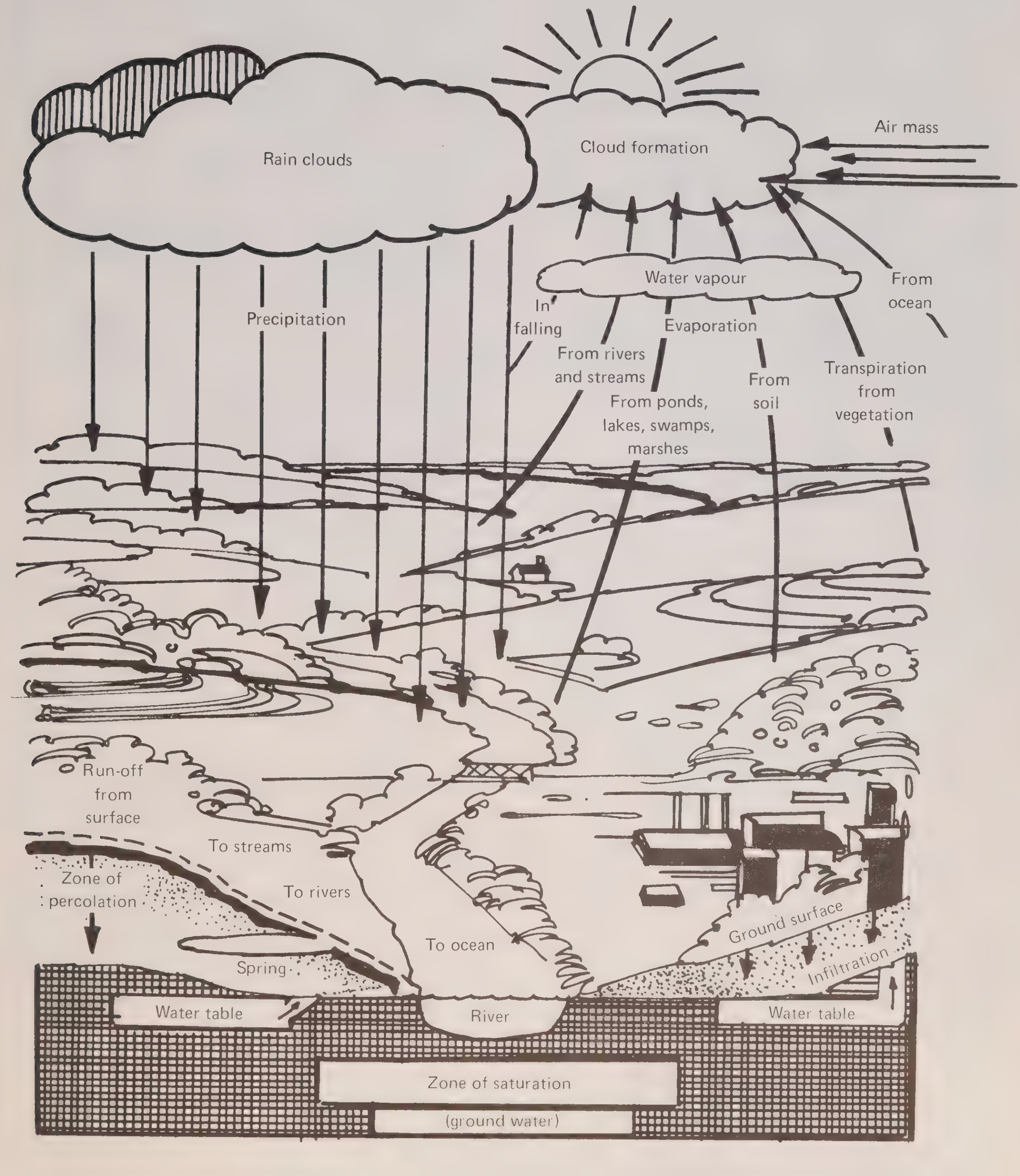
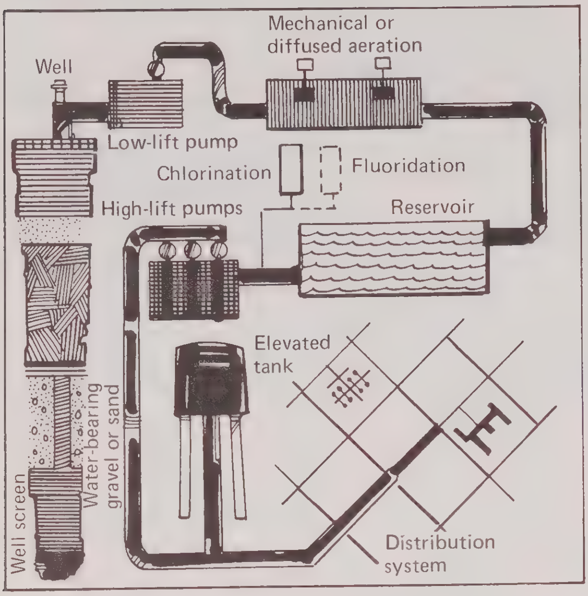


Figure 4.10

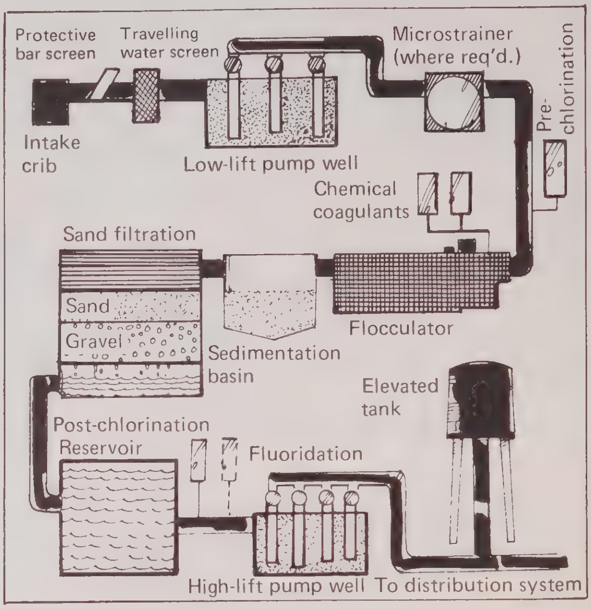
Ground Water Supply



Source: *The Water Story*, p. 21.

Figure 4.11

Surface Water Supply



Source: *The Water Story*, p.20.

Illustration by Greg McEvoy, Student, High School of Commerce, Ottawa. 1977

Potable Water – Coming Up!

★ Draw a representative diagram for your water supply. If your supply comes from a utility, have your teacher or one student in the class contact the company to obtain information on the actual system.

Some general information on water supplies follows:

> *Water Supply – Ground Water Source.*
>
> Raw water is obtained from a water-bearing strata – usually sand or gravel – and drawn into the well through a screen to prevent clogging of the shaft by particulate matter. Low-lift pumps draw the water to the surface where, should conditions warrant it, it may be aerated or chemically treated before being passed to a storage reservoir. Following chlorination (and possibly fluoridation), high-lift pumps transfer the water, as required, either directly into the distribution system or to a high level storage tank ready for distribution.
>
> *Water Supply – Surface Water Source.*
> Raw water drawn from a surface supply is first passed through a protective bar screen to remove large objects and debris. Next, a travelling screen removes smaller solid objects before low-lift pumps raise the water to the treatment plant. Should water conditions demand it, a microstrainer is employed to remove algae and large particulate matter. Following pre-chlorination, chemical coagulants are added and the water is passed through a flocculation tank where gentle mixing takes place prior to settlement in a sedimentation basin. Any finely suspended matter still remaining in the water is then removed in the filter bed, from which the water is passed to a reservoir. Finally, following post-chlorination (and fluoridation in some cases), the now treated water is pumped to an elevated tank and into the distribution system.
>
> From *The Water Story*, p. 21.

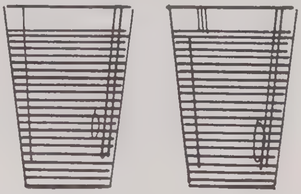
★ 1. By research in the library, determine the various methods used to purify water so that it is drinkable (potable water). Determine which of these is used in the system that supplies *your* water.

2. List and, if possible, discuss the various sources of energy required to carry out this process. Use the illustration to identify the "energy slaves" operating in your water supply. Are there some that are missing in the figure? (See p. 38, bottom.)

3. To *purify* the water will require an appropriate energy input per litre. What has been happening over recent years regarding the things that must be removed from our water before it is potable? Are there things not being removed that should be? What does this imply about the energy required to produce an appropriate system and to continue to operate it? Develop this idea and include the problem(s) raised by increasing consumption rates.

How Is Water Made Safe to Drink?

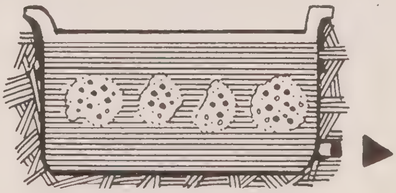
When your community accepts the responsibility of supplying you with drinking water, it has to be very sure that the water is of good quality, and is safe for you to drink. Sometimes this is not difficult – as when people live where there is a plentiful supply of clear, sweet water. Many people, however, live alongside rivers or lakes where the water is cloudy or dirty. Polluted water has to be very carefully treated before it can be supplied to people to drink.



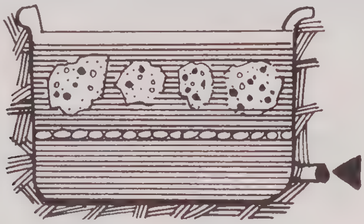
After the water is drawn from the lake or river – or in certain areas from very deep wells – it is first passed through a grid of large metal bars that stop any pieces of wood, tree branches or large objects from entering the treatment plant.

Next, depending on the quality of the water, it may be passed to a tank – often about as big as the living room in your home – where chemicals are mixed with it. These help make the very small particles of matter in the water cling together until they become heavy enough to sink to the bottom. There, the sludge (which is really a kind of mud) is removed and washed down the drain.

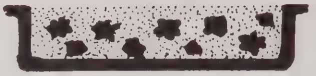
The chemicals do not remove all of the matter that might be in the water, however. In the next process, the water is passed through a filter. Here, the water is gently and slowly passed through a deep bed of sand and gravel, or other materials, which are mixed so that the holes between the grains of sand, etc., become smaller and smaller. As the water passes between the grains, the minute particles of matter are trapped and held. At the bottom of the filter, the now clean water is collected and piped to a storage tank within the plant.



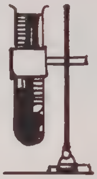
With all the dirt being stopped and held in the filter, it sooner or later becomes so full of mud that no water can pass through it. When that happens, the plant operators open and close a series of valves and pump some of the clean water from the storage tank back through the filter from the bottom. This washes out all the dirt which is collected in a separate pipe and led away to the drains.



Once the clean water reaches the storage tank in the plant, it is practically ready for people to use. The last thing to be done is to kill any germs that might possibly have slipped through. This is done by adding a small amount of the chemical called chlorine. Only enough is added to kill the germs and protect the water on its way to your house.



Now the water is ready to drink. To make sure that the chlorine is still working and still protecting you, waterworks experts visit points around the distribution system and take samples of the water in the pipes. These samples are taken back to a laboratory and tested. The amount of chlorine they find is called a residual – and only a very little shows in their tests, about three parts of chlorine to every million parts of water.



From *My Water Book*, p. 14.

The Killer Chlorine

To Make Our Water Safe

Just taking the apparent impurities out of a raw water is not enough, though. There is always the chance that the source of the raw water may have become contaminated with sewage wastes and there are few water sources in southern Ontario, for instance, that do not contain a trace of such contamination.

As well, this sewage may originate from a system collecting the wastes from either a homestead, or collection of homes in a municipality, or from a farm discharging animal wastes. In either case, the chances are that harmful bacteria may be present in the water – pathogenic organisms that transmit disease between mammals.

To safeguard our water, the Ministry requires all such surface supplies to be chlorinated. In some treatment plants, chlorine is applied before treatment as well as after in order to prevent a possible build-up of micro-organisms at any point within the plant. The main point of application, however, is as the water leaves the filters, and sufficient chlorine is injected so that, after neutralizing any harmful bacteria present in the water, a residual will be left. In this way, assurance is always there that sufficient chlorine has been added and that the water is safe.

The Chemistry of Water Disinfection

Chlorine (Cl_2) is produced, chiefly, by electrolysis from sodium chloride (NaCl), or common salt. It is supplied commercially as a liquified gas under pressure, and vaporizes at -34°C. When it becomes gas, chlorine acquires a greenish-yellow colour and a very pungent odour.

When chlorine is added to water, the following reaction takes place: $Cl_2 + H_2O = HOCl + HCl$ as Chlorine plus water produces hypochlorous acid plus hydrochloric acid.

The hydrochloric acid is neutralized by carbonates which are naturally present in water. The hypochlorous acid is a powerful disinfectant. Part of it is quickly used up in killing the bacteria in the water. The remainder stays in the water as a residual – a sort of safety margin which keeps the water bacteria-free until it reaches its point of use.

This residual can take two forms – either a combined or a free residual. In the combined form, the hypochlorous acid combines with ammonia (which is present in most waters) taking a relatively long time to kill bacteria, but remaining very stable. Thus, for a large water system, it is desirable to keep a combined residual in the system to assure safety from the treatment plant to the farthest point of supply.

By adding more chlorine and producing hypochlorous acid, the ammonia may be overcome. The hypochlorous acid remaining becomes a free residual which, although not as stable, has a shorter bacterial killing time than a combined residual.

Maintaining an adequate residual is the only way of assuring that water is safe. Its presence proves that enough chlorine was added to fully disinfect the water.

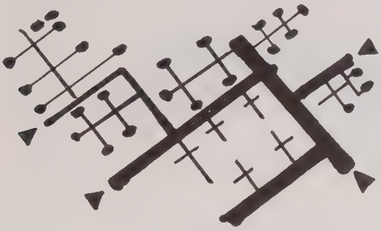
From *The Water Story*, p. 16.

★ Now, find out how and why *fluorine* is added to many water supplies. Does it do the same thing as chlorine or something different? How does it perform the job it is intended to do?

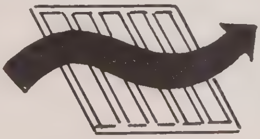
Out of Sight – Out of Mind?

When you have used water, you let it drain away. By pulling the plug in a sink, or by flushing a toilet, you let the now-dirty water swirl around and disappear from view. Where does it go, and what happens to it?

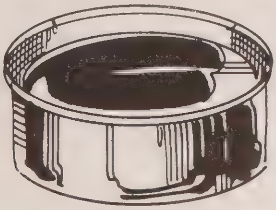
Where Does All the Waste Water Go?
When the waste water leaves your home it is taken through a series of pipes to the municipal sewage treatment plant. On the way, the pipes collect the wastes from many other homes and factories until, by the time the main sewer reaches the treatment plant, almost as much waste water is flowing down this pipe as there is fresh water being pumped up the other pipe from the water treatment plant.



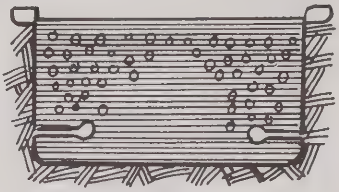
Once the wastes reach the treatment plant, work starts on making the water clean and safe again. Once more, the first stage is to pass the flow through a grid of metal bars to remove the rags and larger items of waste.



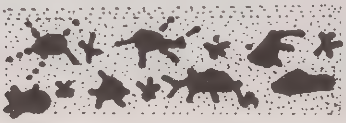
Next, the waste water flows into a tank where it is allowed to be very still – without fast movement or waves. This allows the solid matter to settle to the bottom where it forms a thick sludge – like mud. This sludge is removed by pumps to another tank where it is further treated before being trucked away as a liquid or a dry cake to be used on the land by farmers. The water in the tank, still far from pure, is allowed to overflow gently into a channel leading to the next, and very special, process.



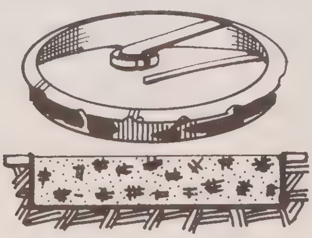
The next thing to happen to the waste water is that great quantities of air are forced through it – rather in the way you might blow bubbles in a glass of water through a drinking straw. Bubbles that form at the bottom of the tank, where the equipment is located, rise to the surface and cause the water in the tank to become thoroughly mixed. In another system, a machine like a giant mix-master stirs the surface of the water and mixes the wastes in the tank.



The air that is forced through the water helps a special type of bacteria to grow and work at destroying the bad things that are still in the waste. These "bugs" help us to make the water safe and could not live if we did not feed them enough air. When the water leaves this tank, having been there for several hours, it is beginning to look quite clean.



But, it's not yet ready to be put back into the lake or river. It still has some very small pieces of waste mixed with it – pieces that are almost too small to see. To remove them, the waste is once again put into a tank and allowed to remain very quiet and still. As before, the small pieces settle to the bottom and are removed, and the now clear water overflows from the top. Having been given a dose of chlorine to kill any remaining germs, this water drains away to the river or lake and merges with the other water.



All that is now left to do is to treat the sludge that has been pumped away from the bottom of the two tanks where the water is kept still and quiet. The sludge is kept in large, circular tanks that are tightly closed. Here, where there is no oxygen, a different type of bacteria go to work for us and make the sludge safe so that it can be used by the farmers to condition the soil of their fields.

From *My Water Book*, p. 15.

Figure 4.12

Pollution Control — Primary Treatment

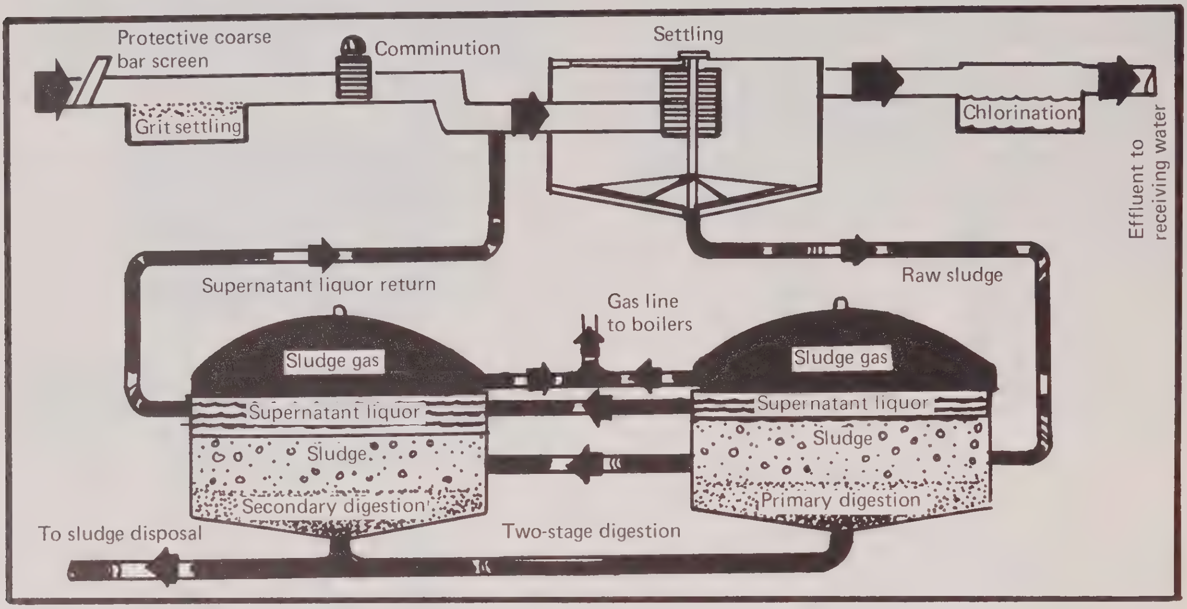
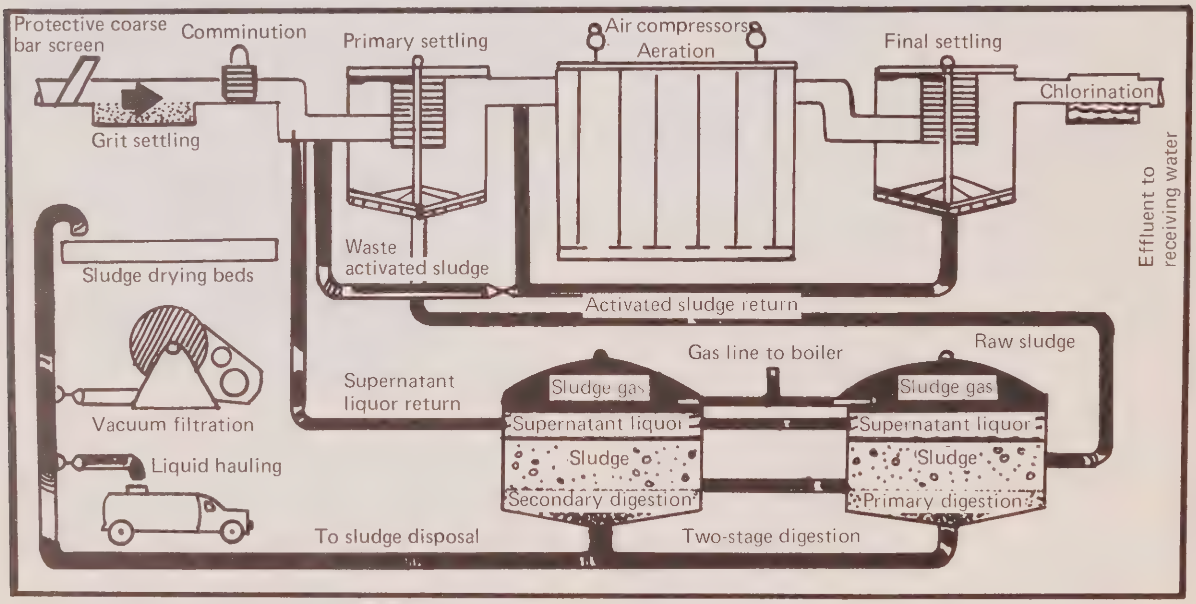


Figure 4.13

Pollution Control — Secondary Treatment



Source: *The Water Story*, p. 18.

★ Draw a representative diagram for your sewage-treatment system. If the sewage is treated by a utility, have your teacher or one student in the class contact the company to obtain information on the real situation applicable to you. Some general information on sewage treatment follows:

> *Primary Treatment*
> Primary treatment is mechanical in nature. Settling tanks are used to remove the settleable solids, floating scum and grease from the wastewater. This form of treatment is used only when it will meet the water quality requirements of the receiving body.
>
> Settling tanks (clarifiers), equipped with sludge and scum removal mechanisms, provide a detention period of approximately two hours for the incoming wastewater. This detention period allows the waste particles to settle to the bottom of the tanks, from where it is removed by pumps for conditioning prior to disposal. The sludge removed is pumped to a digester or other treatment facility, where it is processed or dewatered before final disposal.
>
> Primary treatment usually precedes biological treatment, which is carried out in secondary plants.
>
> To summarize: Primary treatment removes the heavier particles, scum and grease from the wastewater. The effluent produced is of a lower standard of quality than is achieved in complete treatment. The amount of solids removed ranges from 40 to 60%.
>
> *Activated Sludge Treatment*
> The activated sludge process is a method of complete biological treatment which produces a high quality effluent.
>
> This is a secondary process, usually carried out following primary treatment. It removes the finely divided, suspended and dissolved materials remaining in the wastewater.
>
> Biological communities of micro-organisms are developed and maintained in aeration tanks where they are supplied with a plentiful supply of oxygen. The air supply can be provided by compressed air, which is piped directly into the tanks, or by means of mechanical agitators, which revolve and disperse the liquid surface to effect transfer of atmospheric oxygen into the tank's contents. Besides providing dissolved oxygen for the micro-organisms, the air, or agitation, also produces a roll in the tank and prevents settling of solids.
>
> As the organic impurities are assimilated by the micro-organisms, the resulting sludge formation is light and flocculent and can readily be settled. This sludge is the vehicle upon which the bacteria grow and provides the means for maintaining the process. This sludge floc is referred to as activated sludge because of the biological communities growing in and upon it.
>
> Final settling tanks provide the means for removing and reclaiming this sludge floc. As the effluent from the aeration tanks passes through these settling tanks, the settling sludge floc is removed and returned to the process by means of pumps or air lifts and is discharged into the aeration tanks again, along with the effluent flowing from the primary settling tanks.
>
> To summarize: Air is supplied to the micro-organisms, which in turn oxidize the finely divided, suspended and dissolved organic materials in the wastewater. This provides a high degree of purification and a clear effluent. The amount of solids removed ranges from 90 to 95%.
>
> *Extended Aeration Treatment*
> The extended aeration process is another method of biological treatment that produces a high quality effluent.
>
> This process is identical to the activated sludge process in its biological application but has no primary settling, and the solids contained in the wastewater are oxidized through an extended aeration period.
>
> *Tertiary Treatment*
> Secondary treatment plant effluents can create some undesirable conditions in some receiving streams through adverse effects on the dissolved oxygen levels, which result in unwanted changes in the living organisms of the streams. Also, these discharges can bring about excess growth of algae and other aquatic plants.
>
> To arrest these conditions, an advanced type of treatment called tertiary is being developed as a third or "polishing" stage to follow conventional secondary treatment processes, for the further reduction of organic content. This will improve receiving water conditions as far as the dissolved oxygen levels are concerned. Another important result of tertiary treatment is the reduction of nutrient levels which algae utilize for growth.
>
> No tertiary treatment form is typical. This third stage of cleaning up wastewater must be adapted to the particular need of the receiving water concerned.
>
> *Chlorination*
> Chlorinating facilities disinfect the effluent before discharge from a plant. In most cases a chlorine contact chamber serves this purpose. In this chamber the final effluent undergoes a detention period of 15 to 30 min to ensure good contact with the chlorine. The effluent outfall sewer, running from the plant to the receiving waters, is sometimes used to chlorinate the effluent in much the same way as the chamber process.
>
> From Ministry of the Environment, *Introduction to Popular Treatment Methods* (Toronto: Queen's Printer, 1975).

Waste-Disposal Methods

As you have seen, the major use of water is in the toilet. Perhaps we should reconsider the treatment of human waste.

There are a number of ways of classifying waste-disposal systems. One method is by the processes that occur to the human waste.

Infiltration. This is the oldest method of waste disposal and still probably the most widespread. The waste is fermented in a pit or container, and allowed to infiltrate the soil. This process can take place with or without water, but the digestion process does slow down at lower temperatures. The capacity of the soil to absorb the sewage is critical, and sufficient area must be allowed for dispersal of the effluent. Health problems can be caused if contaminants leak into the water tanks.

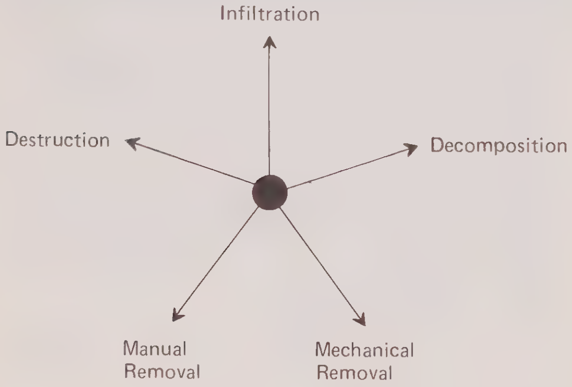
Manual Removal. There are three cases where Infiltration cannot be used; extreme cold, low-porosity soil, or too great population density. The most common method in such instances is to manually remove the waste to a distant leaching pit or sewage lagoon. Chemicals are often used to reduce smell and danger of contamination before the waste has been disposed of. Water is not usually used in these systems.

Mechanical removal. The population density in cities and towns precludes the use of Infiltration, and also, usually, Manual Removal, as the disposal point (river, sea or treatment plant) is too far away. At the same time the concentration of people and resources permits a large capital investment in networks (roads, sewers, water supply) and so mechanical means of removing the waste from the dwelling are employed. Often large amounts of water are used.

Destruction. An age-old use for human, as well as animal, waste has been as fuel. Recently this method of disposing of waste has been applied in the form of incinerating toilets. Although this is a new development, and has not consequently seen wide use, it represents a waterless, sanitary method whose only disadvantage is possible pollution of the air. It also involves high energy conversion.

Figure 4.14

Waste Disposal Methods



Source: W. Rybczynski and A. Ortega, *Stop the Five Gallon Flush* (Montreal: McGill-Queen's University Press, 1976).

Decomposition. This represents an alternative to the anaerobic putrefaction of waste that takes place in all septic systems. The disadvantage of these systems is that there is no oxygen present, no heat build-up occurs, and pathogenic bacteria and other parasites take up to 6 months to be destroyed. In aerobic decomposition, the high temperatures generated by the oxidation, destroy the pathogens in a matter of hours. Though the processes have been understood for some time, not enough work has been done on this form of waste disposal, which has great potential, and can result not only in efficient waste disposal, but fertilizer manufacture as well.

From W. Rybczynski and A. Ortega, *Stop the Five Gallon Flush* (Montreal: McGill-Queen's University Press, 1976).

★ Which one of the methods described above does your home currently use? Select or design a method that would be best suited to change the one your home uses now to a less wasteful one. Suggest alternative waste-disposal methods that might be introduced in the future and in what type of population setting they would be most efficient.

The Expanded System

★ Draw a diagram similar to that in the accompanying illustration ("A Water-Sewage System"), but one that is *realistic* for your home. Indicate the locations and addresses of the appropriate water-treatment and sewage-treatment plants. Where is the water tower in the system closest to your house?

★ Have your teacher try to arrange a class visit to one or both of the above-mentioned plants. Redraw the diagram produced in the previous activity in the form of a flow chart with a "block" for each stage of the process. Beside each block, list some energy inputs required to maintain the system flow rate. Energies listed should really be added to those calculated in the activities in Section 4 related to using hot and cold water in your home!

★ Think about the energy required to *build* a water-supply/ sewage-treatment system and the natural resources converted to supply this energy. List a few.

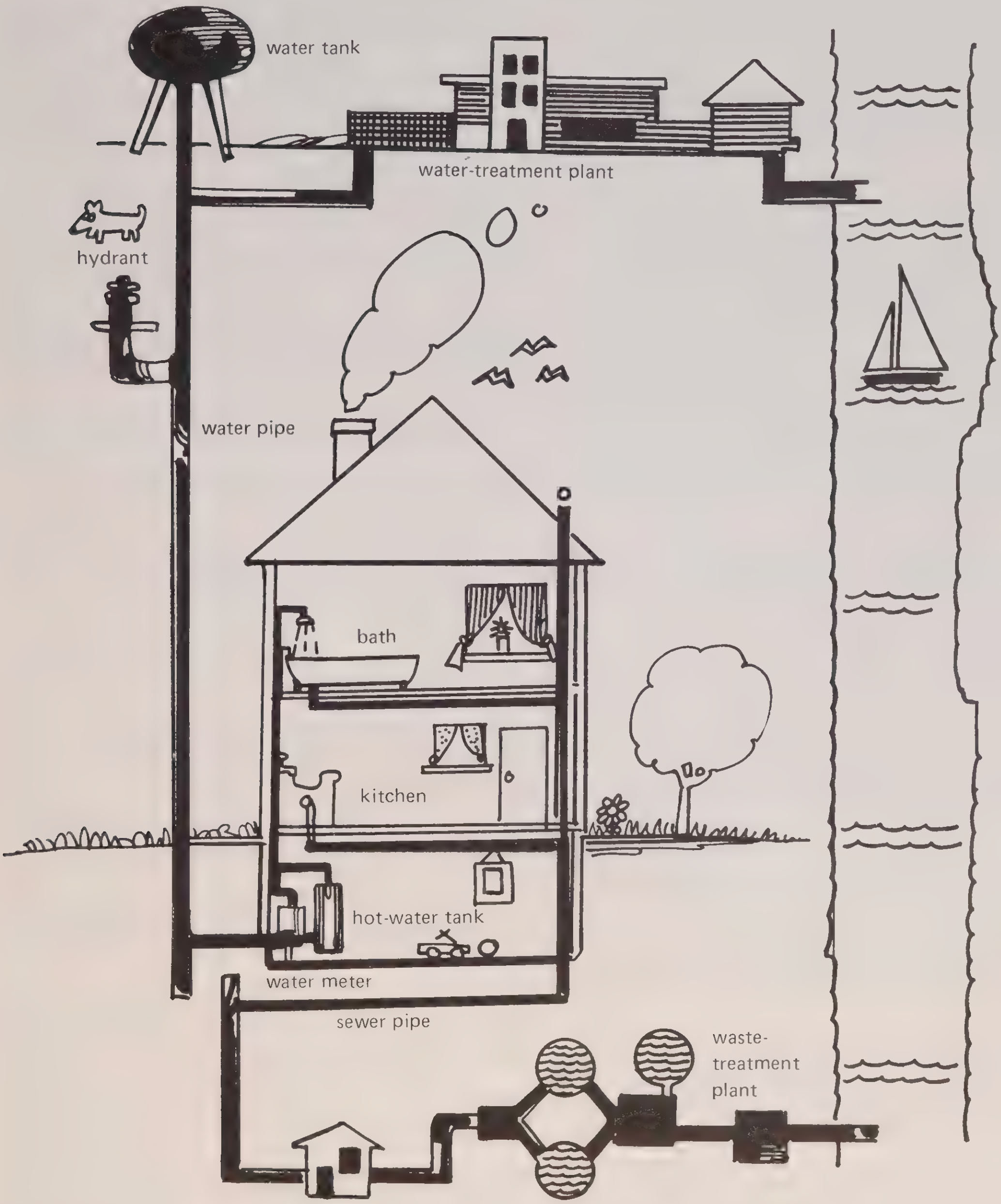
Integrated Systems

★ Suggest a couple of alternative designs for water systems based on your study of water usage. Can we recycle water with less energy input? Do some research on Canada's CAN WELL project.

As you have seen, the water/sewage system in your home is linked up in quite a direct way with the hydrologic cycle operating on the planet. Now, what can you do, as an individual, to decrease the demand for energy conversion within this system?

Figure 4.15

A Water/Sewage System



Source: Adapted from *My Water Book*, p. 12.

6. Action Plans

Introduction

This section includes some activities that are best done after concluding your study of water. In addition, some research topics have been attached for those interested in further study.

It is hoped that by this time you will have a real appreciation for the complexities of the processes that purify and supply you with water and that accept and treat your sewage. It is our *lack of knowledge* of these "hidden" energy-converting processes and our associated *poor judgement* in making decisions on water use that in a way epitomize two of the central problems in a *consumer* society.

Things to Do on Concluding This Unit

★ After your group or class has completed all the assigned activities in this unit and has had an opportunity to discuss the results, go back and look at the value continuum you produced for the three questions in the activity entitled "What Do You Think?" in Section 1. Re-determine your individual and group position on each continuum.

★ From your study, develop a list of *changes* in attitudes or values that will have to take place to produce significant water-conservation practices in Ontario. Rate each of these as to whether they are realistic (as opposed to idealistic), short-term (a few years) or long-term (twenty years or a generation).

★ As a result of this study, develop a one-page set of *general guidelines* for the conservation of water in the home. Produce a quantity of these and distribute them to homes in your community. Post them in your own home first!

★ Develop a list of suggestions on how the school could save water. Discuss these with the students' council, building custodian, and principal and develop plans of action.

★ Develop a special list of *specific things* that can be done to cut down water consumption in the *high-use areas,* as you determined them through your study. Implement these in your own home first before distributing the list to others!

★ Start a project in your school or community to reduce the "flush volume" in toilets. After learning how to do the job, advertise and "offer your services" to the community either to do the job or to show how it should be done.

★ Make a part-time job out of the following. If you can't actually do the job, offer your services on a "consulting" basis:

1. fixing a leaky tap

2. insulating accessible runs of hot-water pipes

3. checking the hot-water temperature and adjusting the thermostat on the hot-water tank

4. reducing the volume of water used in a toilet flush

5. presenting ideas on water conservation (See the activities above.)

The next time, and every time you drink a glass of water, think about it!

Research Topics – If You Have Time and Interest

★ The following list represents a few things or areas you could look into to expand your knowledge of water:

1. Why is water important to all life on earth?

2. What use is (or could be) made of rain water and other forms of water that fall on the roof?

3. Towards a modern outhouse – no water needed. Investigate the new designs being proposed.

4. What are the unique properties of water?

5. What soaps, detergents, and so on are bio-degradable (what does this mean)?

6. How are special shower heads used to cut down on water volume? Locate a supply, obtain the price of them, and develop an advertising flyer to distribute.

7. Make recommendations for washing clothes in cold water and for staying away from clothes that require a lot of washing.

8. Why do front-loading automatic washing machines use 50% less energy than do top loaders?

9. Develop the idea of a watershed and determine the ones available in Ontario. Which one are you in?

10. What role do ice and snow play in the water cycle?

11. Do a qualitative study of the wastes put into the water in your home.

12. What use is made of water by industries, businesses, and other sectors of society, and what are the appropriate percentages used by each? What water-conservation measures are being (or could be) taken in these sectors?

13. Design a "solar water heater" for use at summer cottages. Do some research to see if the idea can be used in a permanent home.

14. If you think "13" is an unlucky number, add a few more topics of your own choosing.

7. Support Material

Glossary of Terms

Aquifer. A layer of rock, sand, or gravel usually horizontal, through which water can pass.

Artesian. A term used to describe underground water trapped under pressure between layers of impermeable rock. An artesian well is one that traps artesian water.

Biochemical oxygen demand. The amount of dissolved oxygen (in parts per million) required by organisms and for the aerobic biochemical decomposition of organic matter present in water.

Cesspool. A structure, usually a pit, designed to hold sewage from a residence.

Coliform bacteria. The "coli aerogenes" group. A test for the presence of coliform bacteria is commonly used to determine the presence of fecal coli from sewage.

Condensation. The transformation of water from a vapour to a liquid.

Cone of depression. A conical dimple in the water table surrounding a well, which is caused by pumping.

Consumptive use. The use of water, especially in irrigation, in such a way that it is converted to vapour and returned to the atmosphere.

Drainage basin. The geographical area within which all surface water tends to flow into a single river or stream via its tributaries.

Erosion. The wearing down of the earth's surface by water.

Evaporation. The transformation of water into vapour.

Evapotranspiration. The process by which water, evaporated from the earth and given off by plants and animals, is returned to the atmosphere as vapour.

Fecal matter. Human and animal excrement.

Ground water. All subsurface water.

Hydrologic cycle. The process by which water constantly circulates from the sea to the atmosphere to the earth, and back to the sea again.

Hydrology. The scientific study of the water found on the earth's surface, in its subsurfaces, and in the atmosphere.

Infiltration. The method by which surface water is soaked into the ground through tiny openings in the soil.

Pathogenic bacteria. Bacteria that causes disease.

Pollution. The destruction of the purity of water by impairing its quality to a point where it becomes unfit for the many uses for which it is required.

Porosity. The ability of rock and other earth materials to hold water in open spaces or pores.

Potable water. Water suitable for drinking. Untreated lake water is not generally potable water.

Precipitation. The discharge of condensed water vapour by the atmosphere in the form of rain, hail, sleet, or snow.

Reservoir. Waters held in storage in either artificial or natural basins.

Settling basin. An artificial basin for collecting the sediment of a river before it flows into a reservoir.

Sewage. An inclusive term applied to all effluent carried by a sewerage system.

Transpiration losses. Water consumed by emergent and floating lake plants and voided as a gas through specialized leaf cells.

Watershed. The whole surface-drainage area that contributes water to a lake, or to a river (in the absence of a lake).

Water need. Although water need is often equated with water requirements, it is probably better to make a distinction between the two terms. The term "water need" should be restricted in use to the essential amount of water that must be supplied for the support of any process or means of life. The best example is the human need for 1 L of water per day for the functioning of the human biological system.

Water use. "Water use" is not a term defining an amount of water, but rather a term defining the purpose to which any given body or amount of water is put. It probably should be used as the most general term for this purpose. More specific terms include:

a) *Instream use.* The water in its natural channel or basin. This category includes navigation, recreation, fishing, waste disposal, and hydro-electric power generation.

b) *Extractive use.* The withdrawal of water from its natural channel or basin before use. This category includes water for cooling, irrigation, and municipal and industrial water supply. It should be noted that extractive use does not imply consumptive use.

c) *Consumptive use.* The permanent removal of part of the flow of a water body. Consumption may take the form of evaporation of waters to the atmosphere; the incorporation of water in some product, as in the case of the brewing or soft-drink industry; or it may take the form of the diversion of water from one body to another.

d) *Non-consumptive use.* A type of loan arrangement in which the water is ultimately returned to the water body. Such water may be considerably changed in character as with the addition of wastes in municipal extractions or of heat in cooling extractions.

A Note on the Economic Character of Water

Many authorities have expounded upon the nature of water as an economic commodity or as economic goods. Without venturing fully into this debate, there are some important characteristics of water that must be borne in mind in any attempt to forecast future water demands. The economic nature of water varies according to the use to which it is being put. Any attempt to define the economic nature of water can lead to a complex jungle of moral, philosophical, social, and economic attitudes. A threefold distinction can be made for the purposes of water management and requirement forecasting. These are:

1. *Water as a social-overhead capital commodity.* In many uses, water is similar to public education, roads, and the like. This is particularly true in the case of the use of water for domestic consumption or for the disposal of waste materials.

2. *Water as an industrial raw material.* The major use made of water in the economy is as an industrial raw material, although it may not, in many cases, be incorporated in the product. Industrial uses include the generation of hydro-electric power, the use of water for irrigation, factory processes, and cooling, as well as a product ingredient.

3. *Water as an aesthetic commodity.* The balance between water supply and demand has been altered in recent years by the tremendous growth of the use of water for recreation. Bodies of water are put to many recreational uses: as a means of navigation, for fishing, for swimming, and, lastly, just for the sheer aesthetic pleasure obtained from viewing an attractive body of water, be it a lake or a running stream.

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How often is your water tested for purity?

Part 5, Food

Table of Contents

Introduction 3

1. You and Your Food Habits 4

2. Why Should We Become a Conserver Society? 9

3. Food Technology 10

4. More for Less? 25

5. Suggestions for Further Study 26

6. Bibliography 29

7. Appendix – The Nutrient Content of Foods 31

★ A star beside the text indicates an investigative activity for students.

125 man h/ha

50 000 MJ
construction energy

175 MJ/ha
labour energy

Fuel energy
45 00 MJ/ha

100 kcal

Energy
expenditure
24.5 kJ/min
in football

Daily energy
input
300 J/kg·d
of body mass

Energy
expended in
operation of
cash register
10.2 kJ/min

Serving of
10 ≅ 600 kJ
of food
energy

Serving of
10 ≅ 600 kJ
of food
energy

Energy construction cost and
depreciation of truck

$$\frac{\text{Wt}}{3600} \times \frac{540}{2\,000\,000} \times 4.546 \times 34.8 = \square \text{ MJ/L}$$

Operating cost: fuel consumption
3 km/4.546 L (diesel fuel)

For operation
0.216 MJ/h

Introduction

In this part, we are dealing with two types of energy. In the food-production system, we use the term "physical energy" to designate the amount of energy expended by human beings, their machinery, and services to produce and deliver a product from the natural resource to a predetermined end use for the consumer. In contrast, the "inherent energy" of a particular food product is its nutritive value that is realized, under optimal conditions, through the chemical processes of an animal (human). Nutrition tables use this type of energy value.

When this document was researched and produced, the quantitative (mathematical) interpretation of this part – particularly in the areas of food processing, packaging, storage, and waste – was difficult to determine or, in many cases, unavailable in terms of physical-energy equivalents.

Whether the teacher wishes to pursue a particular food-product production system qualitatively or quantitatively with a class, he or she must first define the boundaries of the system. The natural resource, in the case of food production – the land, may be considered the *starting point* from which the physical energy cost accounting will be made in delivering a specified amount of food to the consumer. Similarly, the *end use* must be specified to indicate the point at which the accounting is to stop.

In a quantitative analysis of the energy required to produce or provide a specific quantity of a certain food item, the same energy unit (whether mass or volume) must be used in all calculations. For example, if we determine the number of magajoules (MJ) of energy in a litre (L) of gasoline, then any additional calculations should be in megajoules per litre (MJ/L).

When obtaining quantitative data from feeder industries – e.g., package makers or processors of various products – the energy cost must be carefully apportioned and pro-rated, especially if the manufacturer produces various kinds, sizes, and quantities of dissimilar products. This apportionment is usually done on the basis of a unit mass, such as a kilogram, or a unit volume, such as a litre.

It is also important to identify the energy-intensive materials (materials that require high amounts of energy) that are used to produce the desired end product (their end use).

The energy equivalents required to build a particular piece of farm or factory machinery and the rate of depreciation are usually equated in quantities of litres of gasoline. For example, to build a tractor with a mass of 1800 kg may require the energy contained in 2.5 kL of gasoline.

When an industry indicates its power cost in dollars, the conversion factors must also be specified. When converting energy to gasoline equivalents, it is essential to know whether the energy was based on a nuclear, fossil, water, or solar source.

It should also be recognized that at each input stage of the particular product being equated other products are made, which, in turn, have their own multiplicity of inputs. For these reasons, it is difficult to equate accurately the energy equivalent for a particular product with so many variables involved. The student of energy must be able to identify the parameters of so complex a system and must recognize that a part of the system that is highly specialized in the production of a single product is extremely vulnerable as a simple ecosystem, compared with a complex one.

Thus, quantitative problems have been presented, in some cases, in dollar values to give the student an appreciation of the cost of production and the loss in waste of food products. As more reliable quantitative data become available, supplements to this section may be forthcoming. In the meantime, the teacher is urged to keep up-to-date on information in this field.

The activities in this section are not presented in order of difficulty. It is hoped that each teacher will find other interesting activities that will lead the student to deepen his or her knowledge of energy and its attendant problems, to become an informed decision-maker, and to develop an energy ethic.

Developing a Perspective

If you are an urban dweller with a small plot of land about your house, your system of survival is very dependent on the larger global system of energy and food supply.

Consider for a moment the various types of energy that flow through your home in the form of goods and services. When you experience a temporary electrical failure, you discover certain alternatives – a flashlight for light, a transistor radio to hear the news, and a fireplace to keep warm. When the automobile doesn't start, you use the public-transportation system or a bicycle. If you can't find a service person to replace a broken window in your house, you can learn to do it yourself.

But what do you do if food runs out? It requires an entire growing season to produce food in your garden. Early pioneers knew how to make their supply of food last through the year until the next harvest filled the pantry. Today, however, most of us are a part of a complex interdependent ecosystem, which expects everyone to do his or her part so that we will not experience a disaster such as starvation.

With the discovery of fossil fuels and the development of garden machinery, only a small fraction of our population is required to work the soil to produce food. Our agricultural system has changed from being labour-intensive to being capital-intensive. Farms have increased in size and have been industrialized by larger, more energy-consuming machinery. The numbers of people in allied industries have grown to assist the farmer increase productivity.

Science has helped agriculture to develop such incredible productivity that marketing surpluses have become a problem today. This development began when humans replaced their own muscle power by animal power, which, in turn, has been replaced by machine energy. Our ingenuity for designing and constructing highly specialized machinery and our recently acquired management skills (largely assisted by the computer) have created an agricultural revolution which may be our greatest asset as we move towards the population explosion of the twenty-first century.

1. You and Your Food Habits

Competitive pressures requiring greater efficiency have made demands on research to develop areas of specialization in agronomy. Computers are being programmed to calculate the cost of feeds and fertilizers for animals and plants respectively on a cost-per-nutrition basis. Automated feeding and watering devices and controlled environmental housing not only produce more farm products, but produce them at a much greater rate than previously. Over the centuries, research in genetics has produced radically different (but not new) farm plants and animals whose growth and productivity meet the increasing demands of the market. Organic and inorganic fertilizers are used to bring plants to their zenith, while newly prepared chemicals – classified as growth hormones, pesticides, fungicides and insecticides – are used to treat the seeds or are capsulated for release at a point in the growth of the plant when most needed. Aircraft, such as helicopters, can envelop orchards and vineyards in a misty shroud of assorted chemicals that will help produce quality fruit and vegetables at the earliest possible date. Where we have been unable genetically to order a type of plant suited to our needs, we have used an alternative approach and have constructed the machinery to suit the cultivation of the plant. New legislation and financially supportive government policies to improve the soil and clean the water through conservation practices have greatly increased the production per hectare.

Feasibility studies are now being conducted by industrial and agricultural processing firms and by large farming units to determine ideal environmental conditions for the production of their plants and animals. Better processing and distribution of farm products have also been brought about by the development of new containers and shipping techniques. Furthermore, the government is constantly reviewing its financial-support policies and its forms of taxation relief in order to assist in the better production and marketing of farm products.

There are limitations, however, to this modern, complex industry. The arable land available can only produce so much edible plant material. In our effort to improve the productivity of submarginal lands (pastureland), we have injected the ruminant animal into the food chain. Overproduction of plant materials today is being fed to herbivores with the result that we are enjoying far too much protein in the form of meat when it is cheaper to obtain it from cereals. The system has other energy stress points in the areas of processing, packaging, storage, and transportation. This makes many of the processed foods, such as juice and breakfast cereal, very energy-intensive. Because our system of food production is so highly specialized, it is very vulnerable to a major breakdown in the flow of inputs. At the present time, we are very concerned about the fossil-fuel energy flow into this simple ecosystem, since most of our technology is built and organized about these non-renewable resources. We must now discover alternatives for the day these resources are exhausted.

Scientists in various disciplines are researching alternatives to maintain our needs for survival. In the meantime, we can do our part to help reduce the rate at which our non-renewable resources are being depleted. It is our hope that teachers and students will find the time and interest to examine and select the various activities outlined in this part, and by seriously applying themselves, gain an appreciation of the extensive waste of energy that accompanies the way we live and eat. Once this is understood, students should seek ways of reducing this waste of energy.

The study is divided into five sections. Different sections focus on the consumer's food habits, on energy conservation related to food, and on food technology. A series of suggestions is outlined to reduce energy consumption and develop a conserver attitude in relationship to food.

In the "good old days", the kitchen stove was heated with wood or coal and served three functions. It heated part or all of the house; it heated a ten-gallon water tank attached to it; and the family meals were cooked on it. If there was any electricity, it was used only to illuminate the room with one electric light bulb. As electricity became more abundant, many energy-consuming appliances for food preparation came into use. Today, we take for granted that these appliances and the energy required to drive them will always be available. Many of us have forgotten or have never learned about alternative methods of processing and preparing foods that would reduce the consumption of energy.

In your lifetime, you may experience shortages of energy – both in power and food! Would you like to prepare yourself for such an emergency? If so, the following activities should give you an insight into the limited nature of our resources both in power and food and will help you to look for alternative ways to cope with such shortages.

★Discovering Alternatives

1. If you have grandparents or senior citizens living nearby, ask them how they managed to prepare their food without electrical appliances.

2. Visit pioneer villages and make a list of the ways you could save on energy when preparing meals.

3. Use your school library to find reference materials that will help you find ways to save money and energy in food preparation. Check with your librarian.

4. Try to prepare the meals for one day by using the ideas and methods of pioneer days. If you are able to do this, find out what the "trade-off" is. ("Trade-off" means that when you save on one thing, you may have to spend what you save in another form. You can't have something for nothing.)

5. For every energy-consuming appliance used in the average home today to process and store food and to make meals, list a piece of household equipment that was used by pioneers in pre-electric times to do the same job. List also alternative methods of storing and processing foods.

6. By using the food-preparation energy costs calculated in the electrical energy part of this guide, calculate the amount of energy saved by using old-fashioned methods of food storage and preparation instead of modern methods.

★Comparing What You Eat

1. Try to recall all the food items you consumed yesterday. Make a list of the different kinds and approximate amounts under the headings Breakfast, Morning Snack, Lunch, Afternoon Snack, Dinner, and Evening Snack. Then make a composite list on the chalkboard and find the frequency of consumption within the class of each item listed. Compare your list and the composite class list of food consumed with Canada's Food Guide. What implications does a poor breakfast have for your daily activities?

2. Using figure 5.8 later in this part, calculate the expenditure of energy needed in your daily activities so that you maintain the body mass and growth that you require. Calculate the energy value of your previous day's food consumption. What conclusion(s) can be derived from the comparison?

3. List the home appliances that were used to prepare the food (see electrical section) and calculate the cost of the energy consumed.

4. Is the cost of your food-energy needs reduced by purchasing convenience foods that require less energy to cook than do home-made foods? Classify the foods you ate yesterday into the two categories – convenience foods and home-made foods. Discuss.

5. Reorder your original dietary list to reflect the most-essential to least-essential foods. Compare your new list with that of others in your class.

6. From your observation of TV, movies, and written reports about people who have endured such hardships as famine, revolution, and war, explain how the survivors coped with severely restricted diets.

★Comparing Costs

Prepare a hot, full-course Sunday dinner in the way your family is accustomed to doing it. Calculate the cost of the food, the waste, the human energy required, and the energy consumed by the electrical or gas appliances.

On the following Sunday, prepare the same full-course dinner. This time shop for food specials, try to reduce waste and leftovers, and organize the food preparation to use less electrical and human energy. How much money did you save in the food purchase? Calculate the physical energy expenditure in purchasing, transportation, and preparation of the meal. See the related activity in the electric energy section and use 18.8 kJ/min as the equivalent energy expenditure by a person preparing the meal. How much money did you save? What would be the saving for 365 such dinners?

For purposes of these activities, the energy expenditure by a person cooking a meal is 18.8 kJ/min.

★Low-Temperature Versus High-Temperature Cooking

Select and prepare a roast by using low-temperature cooking. Compare the nutritive value and the cost to high-temperature cooking. How does the cost of low-temperature cooking compare with using convenience foods that have the same nutritive food value? Discuss this with your family studies teacher.

★Microwave Versus Regular-Oven Cooking

Prepare two identical meals, cooking one in a regular oven and the other in a microwave oven. Compare the energy cost. Include the human energy expenditure in each case. In what way is the microwave oven a saving in terms of energy?

Consumerism

Most people are aware of the fact that media advertising and modern food technology are to a certain extent responsible for impulse buying and an ever-greater consumer desire to use the goods and services offered.

★1. Discuss the socio-economic aspects of energy conservation of each of the following family groups with respect to:

a) bulk purchases of staple foods versus buying small quantities;

b) kinds of foods that may be purchased;

c) convenience foods versus farm produce prepared at home;

d) preservation of foods, i.e., canning and storage, versus buying foods already preserved;

e) waste disposal;

f) growing their own fruit and vegetables;

g) raising their own livestock, poultry, etc.;

h) shopping habits;

i) eating out versus entertaining at home;

j) cost of food consumption per person.

Family A:

Young, married couple living in an apartment and both working.

Family B:

Middle-aged couple with three teen-agers living in a city house with both parents working.

Family C:

Middle-aged couple with five children, mother working at home.

Family D:

Single, working apartment dweller.

Family E:

Young couple living on a farm, wife pregnant, husband working on specialized cash-crop.

Family F:

Young couple living in town with two small children, father unemployed, mother keeping house.

★2. Food chain stores often feature sales (loss-leader items, etc.) that require the consumer to make frequent trips to the store. This adds to the cost of the food items purchased. Keep track of the number of times the family car (taxi, bus) is used to purchase food during a given interval. Record the distance and multiply this by 12.5¢/km for Southern Ontario and 13.2¢/km if you live in Northern Ontario. Add this to the cost of the family groceries that you purchased. With your classmates, make a cost-comparison study on a per-capita basis within an agreed-upon time interval.

a) What possible implications can you derive from making such a comparison study?

b) List the various ways by which you or your family may be lured by the advertising media to the food market.

c) What is impulse buying? How is this encouraged by the food stores?

d) What are some of the results of impulse buying?

Food Consumption

★Obtain the following references from your family-studies or health teacher or from your school librarian:

Department of National Health and Welfare, *Dietary Standard for Canada* (Ottawa: Department of National Health and Welfare, 1975);

Guthrie, H. A., *Introductory Nutrition,* 3d ed. (St. Louis, Missouri: The C. V. Mosby Company, 1975).

★Find out what is meant by "a dietary standard" and "basal metabolic rate (B.M.R.)".

★1. From the references, find your basal metabolic rate in calories per kilogram per day, and convert this to kilojoules per kilogram per day (kJ/kg•d). Under what conditions does this amount of energy pertain? How much more energy would be required if you were running or skating or swimming for 30 min (see *Introductory Nutrition,* chapter 5)?

★2. After exercising, you may become hungry and eat sweets or "robber" foods which are filling and give you the kilocalories (kcal) you need. What is wrong with this type of food consumption with respect to nutritional needs?

★3. Keep a chart (similar to table 5.1) of your physical activities and type of food intake for a day and for a week. See table 5.8 for the energy expenditure of various activities. At the end of the week, calculate your energy intake in relation to your energy requirements beyond your basal metabolic rate. Make a daily bar graph for a week to determine your deficiencies and excesses in relation to food intake and energy output. How would you regulate any deficiency or excess?

★4. Consider the variations in energy consumption within your class or group. How do you account for them?

★5. Examine the contribution of each meal to your energy and protein requirements. What are the class or group results?

★6. At some time or other you may have gone to school without breakfast and later eaten too big a meal at suppertime. What effect does this have on your physical activities and mental alertness? Examine your eating habits to see if your body gets a uniform energy supply throughout the day in relation to your activities.

★7. Canada's Food Guide states that you should have a balanced diet including one serving of a "complete" protein food. Yet, one-third of the world population exists on a 7500 kJ (1800 calories) diet derived entirely from cereals. What is the long-term effect of getting protein only from cereals?

Table 5.1

Physical Activities and Type of Food Intake

Time in hours	Basal Metabolic Rate (B.M.R.) and Activities in kJ/kg·h	Classified foods	Amount	Energy value

★8. Refined, over-processed foods – such as some breakfast cereals, liquid breakfast products, and bakery items – lack necessary bulk, minerals, and vitamins. The manufacturer, however, does add synthetic ones. Check a cereal package for the list of ingredients and list the synthetic additives.

★9. Examine the family groceries purchased for a week. Take out the obviously over-processed foods. What proportion of your purchases does this represent? Can you find a suitable natural-food replacement for the over-processed products? Would your family agree to your suggested changes? Would you save any money by making such changes? What energy is saved by the suggested changes?

Energy Expenditure

We are dependent exclusively upon food for our source of energy. The quantity of energy we normally use is reflected either by a gain in body mass, as the energy taken into the body is stored, or by a loss in mass, as the body consumes itself for fuel.

Energy may be defined as "the capacity for performing work", and work may be expressed in energy units. Work is further defined as "the force multiplied by the distance" (the force acting upon the body to produce motion multiplied by the distance the body is moved). A unit of work is completed when a force of 1 N (newton) acts through 1 m. A newton is the force acting on a mass of 1 kg to produce an acceleration of 1 m/s^2 or, simply stated, the force required to support two golf balls or a D-cell flashlight battery. This means that if a pair of golf balls is lifted through a height of 1 m, the work done is a force of 1 N times a distance of 1 m, which amounts to 1 N x 1 m = 1 N•m (newton metre) = 1 J (joule). If this work is done in a unit of time, the units are then expressed as a unit of power or as a number of joules per second. 1 joule per second = 1 W (watt).

The unit used for expressing work is the joule. Kilojoules and megajoules are also used. In metabolic work, the calorie used is usually the large Calorie or kilocalorie. This unit of energy (kcal) is used in the study of energy balance in biologic systems; it is the amount of heat required to raise the temperature of 1 kg of water 1°C (at 15°C). But now the calorie is obsolete.

We now use the joule or kilojoule, and a kilocalorie is equivalent to 4.2 kJ. A watt is equal to a joule per second.
1 kcal/s = 4.2 kJ/s = 4.2 kW
1 kcal/min = 4.2 kJ/60 s = 0.07 kJ/s = 70 W
It must be remembered that humans are capable of both using and storing energy. Whether energy is stored or not depends upon the amount of energy used. If more energy in kilojoules is consumed than is used in daily activities, the energy will be stored, usually in the form of fat; if more energy is used to do work than is consumed, then fat will be lost.

The measurement of energy in humans, during daily-life activities, is based upon the relation between energy production and the consumption of oxygen. The energy stored in most foodstuffs (kilojoules) can be liberated in the human body and used to maintain body functions either during quiet rest or during physical activity.

The energy supplied by foodstuffs can be measured. This chemical energy is determined by burning a measured quantity of the material under question in a bomb calorimeter. This is a method of measuring the heat energy liberated by the material. Another often-used method for the determination of energy value in food depends upon the amount of oxygen used in burning the food material. The oxygen can be converted to kilojoules by multiplying by 21 (or 1 L of oxygen uptake equals approximately 21 kJ).

The same basic methods are used to measure the heat directly produced as a person lies quietly or is active. In this case, the amount of oxygen consumed is used to calculate the energy expenditure. The measurement of energy expenditure (or exchange) can be determined accurately in the laboratory while a subject rests, rides a bicycle, steps up and down on a bench, or walks on a treadmill. Over the last fifty years, it has been possible to measure the energy cost of many daily activities that might occur in industry or on a farm, as well as such regular activities as walking, running, or swimming.

Considerable work has been done with the regular activities, and as a result it is possible to estimate with a high degree of accuracy the energy expenditure of these activities using only the speed of walking or running or the stepping rate (in these cases the oxygen uptake is not measured). Although there are individual differences in the energy expenditure during such regular activities, the differences are not great from one person to the next. Factors such as body size, level of physical fitness, and skill in performing a given task usually result in differences in energy expenditure of no more than 10% and do not vitally affect the estimates.

The cost of walking and running on the level and up a grade at various speeds has been extensively studied. It has been shown that the net cost of maintaining a speed over 1 kg of body weight and 1 m of distance is a constant. The constant is different for running and walking due to the changes in efficiency.

There are three categories of speed: walking at 2 to 6 km/h; walk-run at 6 to 9 km/h; and running at over 9 km/h. The energy costs of the speed categories can be summarized as follows:

1. *Walking* (speeds of less than 6 km/h or 100 m/min)

Energy expenditure per kilogram of body mass per minute = $0.38\,(7.3 + \%\ \text{grade})v$ J/(kg•min), where v = average speed of walking in metres per minute, % grade = rise over the distance travelled (sine of the angle), and 0.38 is a factor representing the energy equivalent of lifting 1 kg through a height of 1 m – energy requiring a force of about 10 N through 1 m, that is, 10 J.

2. *Running* (speeds of more than 9 km/h or 150 m/min)

Walk-run speeds between 6 and 9 km/h have not been accurately measured, since for most people they represent a speed too fast for a comfortable walk and too slow for an efficient running action. Level running: energy equivalent per kilogram of body mass per minute = $4.2v$ J/(kg•min), where v denotes the speed in metres per minute.

3. *Bench-stepping*

In a similar way, the energy cost of stepping up and down on a bench can be estimated as follows:

Energy expenditure per kilogram of body mass per minute = $[38\,(f \times h \times 1.3) + (8.4f)]$ J/(kg•min), where 38 represents the expenditure for every kilogram raised through a height of 1 m, f is the stepping frequency per minute, h is the height of the step in metres, 1.3 is a correction factor to account for the energy used to come down from the step, and 8.4 is a constant to account for the energy used in the forward and backward movement of the body.

Note: The above formula can be simplified to the following form:

Energy expenditure per kilogram of body mass per minute = $f(49h + 8.4)$ J/(kg•min).

The above three cases may be simplified as follows:

Energy expenditure per kilogram of body mass per minute
= $0.38\,(7.3 + \%\ \text{grade})v$ J/(kg•min) *when walking*
= $4.2v$ J/(kg•min) when *running*
= $(49h + 8.4)f$ J/(kg•min) when *bench-stepping*

where v = speed in metres per minute
f = stepping frequency per minute
h = bench height in metres

Examples of Problems

1. a) A 50 kg woman walks at a speed of 55 m/min for half an hour on the level (0% grade).

(i) What is her energy expenditure per kilogram of body mass per minute?

$$\begin{aligned}\text{This} &= 0.38\,(7.3 + \%\ \text{grade})v\ \text{J/(kg•min)}\\ &= 0.38 \times (7.3 + 0)\ 55\ \text{J/(kg•min)}\\ &= 153\ \text{J/(kg•min)}\end{aligned}$$

(ii) What is the energy expenditure of her body per minute?

$$\begin{aligned}\text{This} &= 50\ \text{kg} \times \frac{153\ \text{J}}{\text{kg•min}}\\ &= 7650\ \text{J/min} = 7.65\ \text{kJ/min}\end{aligned}$$

(iii) How much energy does she expend in the half hour?

$$\begin{aligned}\text{This} &= 7.65\ \frac{\text{kJ}}{\text{min}} \times 30\ \text{min}\\ &= 229.5\ \text{kJ}\end{aligned}$$

b) She then triples her speed and runs for half an hour at 165 m/min along level ground.

(i) What is her energy expenditure per kilogram of body mass per minute?

$$\begin{aligned}\text{This} &= 4.2v\ \text{J/(kg•min)}\\ &= 4.2 \times 165\ \text{J/(kg•min)}\\ &= 693\ \text{J/(kg•min)}\end{aligned}$$

(ii) What is the energy expenditure of her body per minute?

$$\begin{aligned}\text{This} &= 50\ \text{kg} \times 693\ \frac{\text{J}}{\text{kg•min}}\\ &= 34\,650\ \text{J/min}\\ &= 34.65\ \text{kJ/min}\end{aligned}$$

(iii) How much energy does she expend in half an hour?

$$\begin{aligned}\text{This} &= 34.650\ \frac{\text{kJ}}{\text{min}} \times 30\ \text{min}\\ &= 1039.500\ \text{kJ}\\ &= 1.04\ \text{MJ}\end{aligned}$$

2. A mountaineer whose mass is 70 kg climbs a distance of 6.4 km along an incline and reaches an elevation of 1280 m higher than his starting point in 80 min.

a) What is the average slope or per cent grade?

Slope = rise ÷ distance travelled

$$= \frac{1280\text{ m}}{6.4\text{ km}} = \frac{1280\text{ m}}{6400\text{ m}} = 20\%$$

b) What was the oxygen requirement expressed in the equivalent form of energy expenditure per kilogram of body mass per minute?

Equivalent oxygen requirement (he's walking at 80 m/min up the slope)

$= 0.38\ (7.3 + \%\text{ grade})v\ \text{J/(kg•min)}$

$= 0.38\ (7.3 + 20)80\ \text{J/(kg•min)}$

$= 0.38 \times 27.3 \times 80\ \text{J/(kg•min)}$

$= 830\ \text{J/(kg•min)}$

c) What was the mountaineer's rate of energy loss in kilojoules per minute?

Rate of energy loss

$$= \frac{830\text{ J}}{\text{kg•min}} \times 70\text{ kg}$$

$= 58.1$ kJ/min

d) What was the total energy expenditure during the climb?

Total energy expenditure

$$= \frac{58.1\text{ kJ/min}}{\text{min}} \times 80\text{ min}$$

$= 4648$ kJ

$= 4.65$ MJ

e) How many kilograms of fat were lost because of this activity, assuming that 1 kg of fat is lost per 32 MJ of energy dissipated?

$$\text{Number of kilograms of fat lost} = \frac{4.65\text{ MJ}}{32\text{ MJ/kg}}$$

$= 0.145$ kg

3. A man steps on a 30 cm bench at 25 steps per minute. His mass is 60 kg. Calculate his energy expenditure in kJ/min.

Energy expenditure per kilogram of body mass

$= (49h + 8.4)f\ \text{J/(kg•min)}$

$= (49 \times 0.3 + 8.4)25\ \text{J/(kg•min)}$

$= (14.7 + 8.4)25\ \text{J/(kg•min)}$

$= 577.5\ \text{J/(kg•min)}$

$$\text{Total expenditure} = \frac{577.5\text{ J}}{\text{kg•min}} \times 60\text{ kg}$$

$= 35$ kJ/min

4. A woman (50 kg) steps up and down on a stair in her home. What is her fat loss over two weeks if she steps for 30 min at 20 steps per minute if the height of the stair is 30 cm? (Assume that 1 kg of fat is lost per 32 MJ of energy dissipated.)

$$\text{Energy expenditure} = (49h + 8.4)f\ \frac{\text{J}}{\text{kg•min}} \times \text{mass} \times \text{time}$$

$$= (49 \times 0.3 + 8.4)\ 20\ \frac{\text{J}}{\text{kg•min}} \times 50\text{ kg} \times 30\text{ min}$$

$= 23.1 \times 20 \times 50 \times 30$ J

$= 693$ kJ

$= 0.7$ MJ

$$\text{Number of kilograms of fat lost} = \frac{0.7\text{ MJ}}{32\text{ MJ/kg}}$$

$= 0.022\text{ kg} \times 1.4$

$= 0.308$ kg

Energy Expenditure Experiment

Note: You must obtain the approval of your local Animals for Research Committee before attempting this experiment with white rats.

★Select four rats out of the same litter, after they have been weaned. Cage each rat and place each one in a different temperature environment, e.g., 5°C, 15°C, 25°C, 35°C. Each rat should be given a wholesome diet and all it can eat. Each day remove the uneaten food and calculate the daily food consumption of each rat. Extend the experiment from two to four weeks.

★Calculate the amount of food consumed over the period of the experiment. Which rat consumed the most (least) food energy? Which rat consumed the least energy for the most gain in body weight? What conclusions might you draw from the observations?

★If you have a treadmill for running or a water tank for swimming, you might design an experiment using white rats (siblings only) to find the energy (food) consumption in relation to strenuous activity (as opposed to inactivity).

★ **Slimming Down by Taking Saunas or Jogging**

People who have too much body mass or who wish to retain their proper body mass engage in various mass-reducing activities. Jogging, cycling, swimming, and games participation are among the most popular. The sauna, with its extreme heat, encourages the human body to dispose of water through perspiration and uses stored energy to keep a constant body temperature. If you have access to a sauna, you might calculate the electrical energy expenditure per kilogram of body-mass loss. Compare this to the human energy expenditure when losing body mass by jogging. (Use 60 kJ/min as the energy expenditure for jogging.)

2. Why Should We Become a Conserver Society?

★**Is the Dishwasher an Energy Saver?**
Check the following specifications of your dishwasher:

1. watts of energy consumed in a given wash cycle – include the drying cycle.

2. the amount of hot water used during a normal dishwashing cycle. (See the electric energy part of this guide.)

★Remember to include the cost, the depreciation, and the maintenance of the appliance. Use an average of 15 a for the life of a dishwasher. You should know how often your dishwasher is used during the day or week. Apportion the cost for one washing on that basis.

★Calculate the number of joules of electrical energy consumed by the dishwasher each time it is used. Calculate the number of joules of electricity or gas energy consumed in heating the volume of water used for washing and rinsing.

★Contrast the cost of using a dishwasher to washing dishes by hand. The latter will include the volume of hot water used and the joules of energy expended by you in doing the work.

★The following controversial statements highlight issues and facts that society in general may not face until, perhaps, it is too late. Discuss and debate the various aspects of these statements; then place your own point of view on a ten-point values continuum. You might then like to add some statements that reflect your own interests.

1. This is a free country; therefore, advertising firms should be allowed to use every means at their disposal to lure the consumer into the market place. It is up to me (the consumer) to learn to resist the temptation.

2. During the various conflicts in Europe that caused famine, loyalty to the cause was shown by eating an "Eintopf Kost" (one-pot meal) once per week to save energy. I do not believe Canadians are ready for this type of voluntary restriction.

3. Most Canadians regulate their food-purchasing habits by their incomes and not by the cost of the food items.

4. It has been stated that a person who goes without food for 24 h will guard; one who is denied food for 48 h will steal; and one who is without food for 72 h will fight. Thus, the difference between peace and anarchy in most countries is only a matter of a few days without food!

5. When our planet runs out of fossil fuels, no amount of wealth (money) can maintain the present level of agricultural activity.

6. The myth that Canada is a country with vast areas of fertile, undeveloped, potentially arable land is deep-seated. Because of this myth, uninformed Canadians are relatively unconcerned about continuing urban and industrial encroachment on a significant portion of the prime agricultural land.

7. If the kitchen (pantry, deep freeze, etc.) wasn't loaded with easy-access convenience and junk foods, I would not eat as much.

8. I raid the refrigerator more frequently when I watch television than when I am actively involved in study or sports.

9. I do not think we have anything to worry about as far as food energy is concerned, because the scientists will find other means and methods to increase food production and the production of artificially prepared nutrients.

10. I believe there still is much land available for food production, otherwise the government would legislate a ban on land use for tobacco farming.

11. It's the government's duty to look after us so we don't have to worry about all the scare tactics from the industrial entrepreneurs whose only interest is to capitalize on our anxieties.

12. When I watch certain ads on TV shows, I get thirsty and go for a carbonated beverage in the refrigerator.

13. What the consumer eats is often decided by chance and not by choice.

14. When it is not caused by a personal health problem, obesity is a form of disregard for energy conservation.

15. Why be concerned about shortages of energy when Canada is giving so much aid in terms of goods and services to other countries, while Ontario is borrowing millions of dollars from other countries to develop our industry?

16. Why speculate and worry about future energy shortages and their consequences? When horse dung was becoming a health and traffic hazard in New York at the turn of the last century, the

city hired a researcher to find a way to remove it. He extrapolated from his research and claimed that the people of New York would be wading through approximately 1 m of the "stuff" before the end of this century if nothing was done about it. What happened? Somebody invented the motor car!

17. Every food item should be clearly marked as to its nutritive as well as energy value. But why should the manufacturer do this when the consumer appears indifferent to such labelling?

★ Fantasy Two Thousand – An Energy Game

The time machine has advanced the clock to the year 1996. The present elected government was successful at the last election by telling the Canadian people they had nothing to worry about from the impending energy crisis. Although the energy (fossil fuels) imports have been reduced by 50% of the annual average of the past twenty years, the government is still hopeful of finding new energy resources within its own boundaries. The massive energy pipeline constructed during the last fifty years is operating at 40% of its capacity. The West's supply of crude oil is almost exhausted. (Many millionaires created by the development of western oil took their paper money with them to live in sunny, fun-filled, tax-sheltered islands.) Only the provinces of the east coast are energy-rich: they rely on hydro-electric power. To date, the expansion of nuclear power for electricity and to power machinery has not been an attractive political platform.

Although severe shortages of power (fossil fuels) have reduced farm production, no one wants to do any physical work on the farm. People have been too accustomed to automated, fuel-energized equipment. Most of the population has moved into the towns and cities to experience the "good, fun-loving life". If necessary, you can always live on the government dole. Very few citizens have started energy-saving home fruit and vegetable gardens. Over 30% of the population is on pension. These people believe they have worked hard during their lifetime and are entitled to the "good life". On top of this, there is a 10% rate of unemployment.

It is now the year 2000. People are beginning to hoard food and materials for shelter and warmth. There is not enough fuel to drive the farm machinery to produce crops! Entry ports fear rebellion when ships dock with fuel and provisions. The government has spent millions of dollars over the past 25 a on special anti-riot equipment and has trained troops to arrest participants in riots caused by shortages of goods needed for survival. The United States has threatened to stop migrations to the south and to reduce drastically the coal shipments to Canada if it doesn't get the contracted hydro-electric power from Quebec and Labrador. Barter is becoming more prevalent within the Canadian economy.

How will you – the cabinet of the government – handle this explosive emergency? From your class, select eight members for a role-playing game. One member is the Prime Minister who will have the final say in the decision-making process. The other seven members will each take one of the following portfolios: Finance; Agriculture; Energy; Immigration and Manpower; Industry, Trade and Commerce; Welfare; and Defence. Your duty is to each develop through your portfolio a policy to minimize the impending food shortage that must be complementary to the overall plan of the Prime Minister's.

Present your plan to Parliament. The class may be divided on a percentage basis of the existing Parliament with its existing parties. The teacher will act as the Speaker of the House. Debate your policies, considering the following: immediate and short-term goals; the consequences of your proposals; the order of importance of your plans; propaganda; and communications through the media to the people.

The following analogy may help you appreciate the amount of physical energy required by Ontario agriculture for all crop production. Ontario farmers require only 3% of the total energy budget for Ontario to produce their food crops. This is approximately equivalent to the total fuel consumption by Ontario vacationers on the July 1 and Labour Day weekends.

In terms of physical-energy requirements to feed one person per year, the best quantitative value available today is the energy found in 4500 L of gasoline. Gasoline contains 34.8 MJ of energy per litre.

★ Hunting for Food

Primitive people first hunted for survival. Today, there are still parts of the world, even in Canada, where people hunt for all or part of the food they need for survival. If you live in an area where hunting is still a part of the means for survival, you might calculate the kilojoules per minute (31.5 kJ/min or more) of estimated energy expenditure by a hunter compared to the energy value of the animal he or she caught!

Slash-and-Burn Agriculture

As the frontiers of North America advanced, people lived on what was available – plant roots, wild fruits, fish, and land animals. The energy obtained from this food all came from the radiant energy of the sun and the nutrients of the soil. Not until the agricultural revolution did the pioneers who came to North America exercise a limited control over plant growth by making clearings and planting seeds. This era became known as the "slash-and-burn" agricultural period!

★ Discuss and list the reasons why this type of farming was short-lived. Why did the corn and tobacco plantations in the southeastern United States move on to other locations after farming in certain areas for a number of years? These plantation owners did not know the two natural laws of thermodynamics at work on our planet; hence, they could not understand a number of environmental problems that plagued their farming enterprises. After you have a grasp of these two laws, you should understand the consequences of their application to food production.

You must recognize first that energy can neither be created nor destroyed, and second that no system of energy transformation operates at 100% efficiency. There will always be some loss of energy in some form at each transfer point. In biological energy transformation such as photosynthesis, approximately 1% of all the radiant energy from the sun is required for chemical bonding in the plants that are available to herbivores (plant eaters). About 10% of this energy in plants is available to the animals that eat the plants. In turn, only 10% of the energy in herbivores is available to carnivores (meat eaters).

Thus, we have plants, the primary producers of food, at the first trophic (feeding) level, followed by plant eaters, the primary consumers, at the second trophic level. The secondary consumers are the meat-eaters who eat herbivores; these are at the third trophic level. Tertiary consumers are carnivores who eat carnivores. Man is both a plant and meat-eater in the food chain.

Remember that at each transfer point in the food chain, approximately 90% of the stored chemical energy of each lower level is not available to animals of the higher trophic level. You should also recognize that much less energy is available to organisms at the higher level because the total amount of energy entering the system is fixed by green plants during photosynthesis.

★ Can you estimate how many kilograms of grain would be required to nourish a student to a mass of 50 kg if he or she got his or her energy by eating beef? How much more would be required if the student was at a fourth trophic level?

No-Tillage, Spray-Plant System

The mouldboard plough, which has been used over the centuries to break, aerate, and prepare the seedbed for planting, also made the soil more permeable for water absorption and reduced the competition by weeds for soil nutrients. Farmers have come to recognize this "conventional" method of ploughing, discing, and harrowing as the best way of preparing the seedbed in spite of its inherent problems.

In the spring, climatic conditions may place a time constraint on this system to do all the operations necessary for planting. Between each operation there is a time duration during which the soil must dry somewhat before the next operation can be accomplished. If the soil dries out too much, the seedbed can't be worked finely enough. If it is too wet, it compacts; thus, conventional tillage practices are only as good as the climatic conditions that favour a particular type of soil. Fall ploughing is also done to hasten the spring operation as well as to bury the remains of the previous crop and weeds. However, this leaves the ploughed soil bare to wind and water, allowing them to erode the valuable topsoil.

Recently, this method of tillage has been questioned by agrologists. With the advent of selective pesticides, it is no longer necessary to destroy weeds by the conventional methods. Agricultural research teams are experimenting with a "no-tillage, spray-plant" system. It is an energy-saver in labour, time, fuel, and the cost of machinery. Smaller machinery with a low power demand that may use from one-half to two-thirds less diesel fuel is designed to break the soil with a coulter disc; this is followed by two other discs which break the soil to incorporate fertilizer and seed all in one operation. The only additional operation needed is herbicide treatment for weed control.

This spray-plant system has several advantages in addition to the already-mentioned economic ones. Farmers can plant their seed at the optimum time with respect to soil and climatic conditions. The existing porosity of the soil, which is brought about by previous plant roots and earthworm activity, is not destroyed. The plant residue of the previous crop acts as a surface mulch to prevent erosion and aids in water retention. This spray-plant system is not suited to every crop. It has been proven effective with cereal crops and light to heavy loam soils, with some crop productivity equalling the crops produced by using the conventional tillage methods.

During the era of subsistence farming, the mouldboard single-furrow plough was usually pulled by a team of horses with a combined mass of 1500 kg and a man to direct the plough. Feed for the team of horses per day was 1 kg of oats and a similar amount of hay for each 100 kg of the horses' mass. This consumption of energy allowed the farmer to plough a 30 cm furrow to a depth of 18 cm at a walking pace of 2.5 km/h. Assume that the oats cost $100/t (tonne) and that the hay cost $60/t.

In contrast, a 37.3 kW diesel tractor with a three-blade ploughshare will cut a width of 1 m to an 18 cm depth at a speed of 5 km/h. The fuel consumption varies with soil conditions. For our purposes, we will suggest 150 L/ha of diesel fuel at a cost of 17¢/L.

★1. If each operator ploughs for 10 h, find the cost per hectare for each type of operation.

★2. Which is the cheaper method of tillage? Which method permits greater farmland productivity? List your reasons.

★3. Which method of operation requires more energy per hectare? For energy conversion, use the following values: diesel fuel = 38.4 MJ/L; oats = 3.0 MJ/kg; and hay = 1.5 MJ/kg.

★ 4. a) When the horses are not working, they require only half the amount of oats and hay. The capital investment of the two horses and plough is $800 for the team and $150 for the plough, plus the feed and care by the farmer. Assuming that the horses are not used for work during six months of the year, what is the total investment of the farmer using horses? Compare this to a farmer who has a capital investment of $10 000 in his diesel tractor and plough.

b) If each farmer pays a preferred rate of interest of 10% on a government loan for the capital investment and is permitted to depreciate the capital investment to zero at the rate of 20% a year, which farmer is better off financially?

Note: Livestock cannot be depreciated; when sold, they may be claimed as capital investment and are not taxable.

Figure 5.1 gives comparative energy requirements for the various tillage practices using a 75 kW diesel tractor.

★ Using Figure 5.1 and assuming that diesel fuel costs 17¢/L to the farmer and that cereal-crop yields per hectare are reasonably equal under both systems of operation, calculate the following:

1. the comparative cost of the conventional tillage-planting system to the one-operation system;

2. the cost of only discing and planting by conventional methods compared to the one-operation system.

Energy in Agriculture

***Note:** Although the metric unit, the hectare, is not in wide usage in Canada's agricultural field, it is introduced in these activities as a scientific unit for student familiarization purposes.*

★ Why wasn't Canadian farm productivity as high during the time of subsistence farming as it is today with mechanized methods?

★ It required 30.0 GJ/ha to grow corn in 1975. Use figure 5.2 to calculate what energy was required for each phase of the operation in GJ/ha.

★ The solar energy that is available to green plants in Canada is approximately 5044 x 10^{12} J(ha•a) (per hectare per annum). The green-corn-plant crop produces 7.9 x 10^{10} J(ha•a) of available food energy. Calculate the efficiency of green plants in converting solar energy into food energy for animals.

Figure 5.1

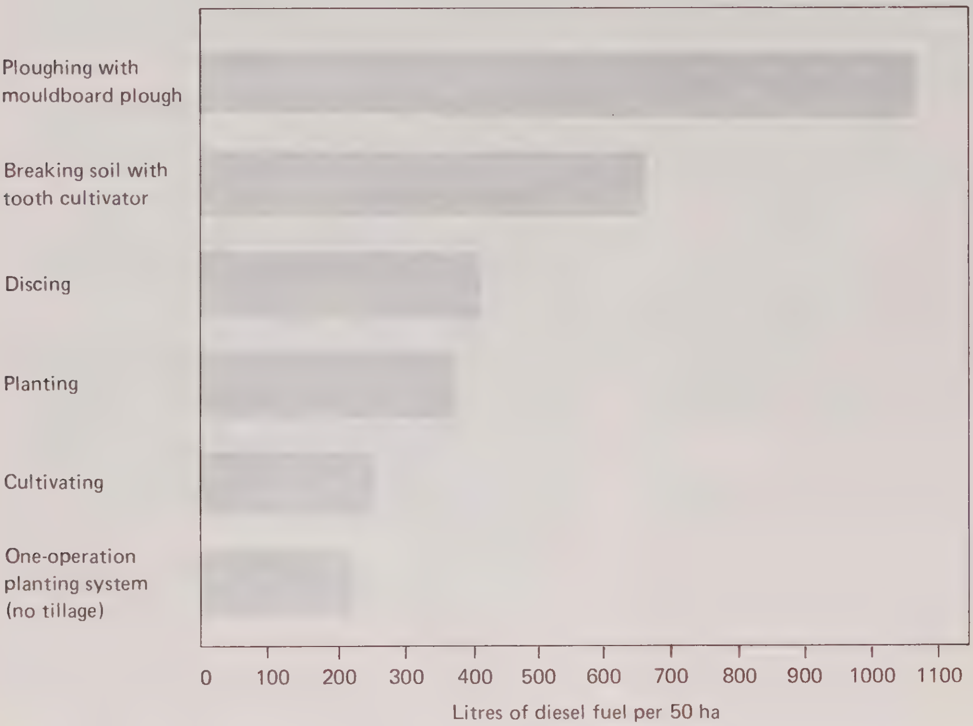
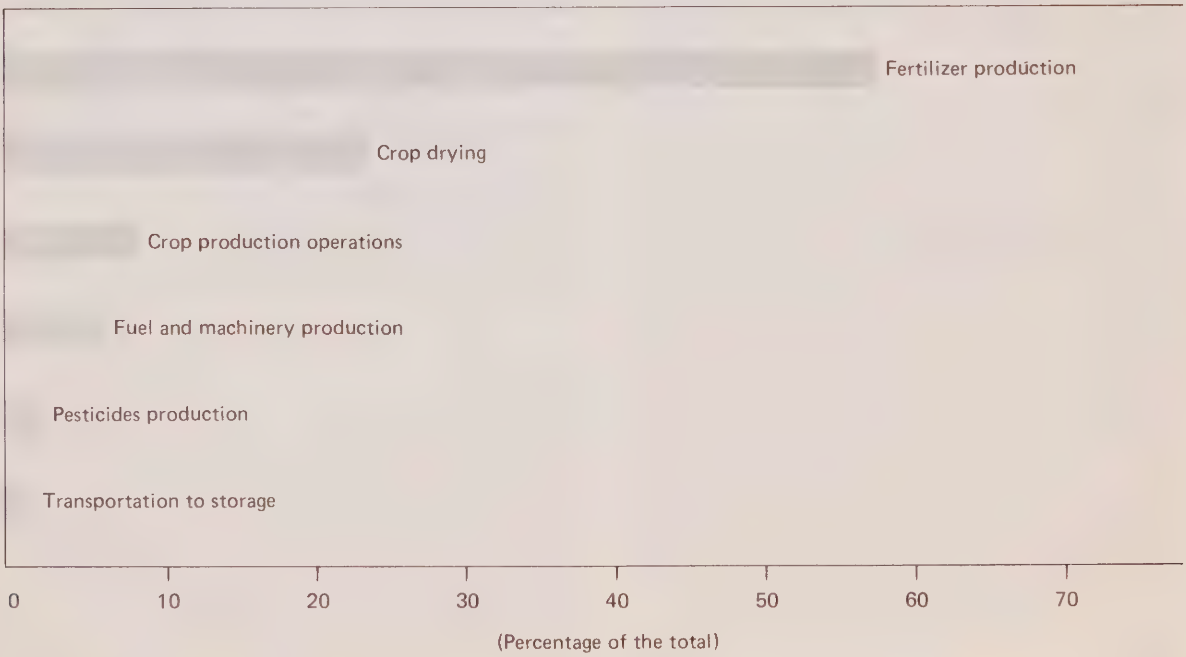


Figure 5.2

Energy Supply to Grain Corn Production



Note: There are various ways to calculate the number of days a particular hybrid corn requires from seeding to maturity. For this activity, you might use 122.5 frost-free days instead of heat units. List the variables that have not been considered in this problem.

Writers in the media have sensationalized the imminent energy crisis; they claim that we will ultimately be forced to trade off ruminants (beef) for green plants (cereals) to obtain our nutrients (especially protein). This is how the vast majority of the world's population survives already. However, nutritionists claim that we must always have some meat to get all the required nutrients.

Humans have long recognized that green plants are far more efficient as primary producers of food than are economically selected livestock. At present, there is a considerable overproduction of cereals – to the extent that we can neither store nor consume them. For this reason,67% (according to United States statistics) is fed to feeder cattle and approximately another 20% is exported to feed livestock. The remainder is milled for human consumption and other by-products. The green-plant energy conversion to beef is not all that great (5.5 kg of corn to produce 1 kg of meat). Until we find a more efficient alternative for grain use, converting it to beef is one way of consuming our surplus grain.

Ontario alone has approximately 1 200 000 ha of unimproved pasture land. This land may be classified into: (a) deep, rough, stony, hilly, or (b) shallow sheetbed of limestone. It has been approximated that a 275 kg beef-animal unit requires 4 ha of the first kind of land on which to feed for six months of the year, while it requires 10 ha of the second kind.

According to estimates, if we average both types of land, the *potential* for grazing land is 0.75 or less of a 5400 kg crop of hay per hectare. The metric equivalent from hay to meat on the hoof is approximately 7.5 kg to 0.05 kg.

Assume that half of Ontario's unimproved pasture land is of the first type and half of the second type. How much meat is put on the hoof? How many cattle could be grazed and how much would each animal unit increase in mass at the end of the grazing season?

From Statistics Canada, find the number of hectares that are classified as unimproved pasture land (land that is not adaptable to current farm machinery or that is classified as submarginal for farming). What would be the waste in terms of metric tonnes of meat produced, if this land were not grazed by cattle? Find the current cost of beef on the hoof and calculate the dollar value.

The nutritional energy value of a 450 kg beef carcass is approximately 2500 MJ, which includes all edible by-products. If you can find out the number of grazing cattle in Ontario and/or Canada, calculate the nutritional energy gained by utilizing a natural resource (unimproved pasture land).

When figures become available for the physical-energy – materials-flow system, calculate the physical (cultural)-energy expenditure in relation to the nutritional energy gained.

The dollar fluctuates on the market, but the energy in a specified octane of a litre of gasoline is constant. Many processing companies are beginning to work out their data regarding costs in terms of megajoules per litre of gasoline.

Food from the Farm to the Table

16.5% of North America's energy is used to provide our food. This energy is used as follows:

Table 5.2

Production stage	Total national energy
Farming	3.1%
Processing	4.8
Wholesale distribution	0.5
Retail distribution	1.0
Cooking – out of home	2.8
– in home	4.3
Total	16.5%

Note that we use more than twice as much energy to cook our food as we use to grow it.

Input Energy for Farming

Input energy to *grow* food includes the following:

1. diesel and gasoline fuel for field work (e.g., ploughing);
2. energy to produce equipment;
3. energy to produce chemical fertilizers;
4. energy to produce pesticides (e.g., weed and bug killer);
5. propane and natural gas for grain drying (to prevent mould growth).

The largest single energy input for growing food is the energy used to produce chemical fertilizers.

★1 L of gasoline contains 34.8 MJ. Express the following amounts of energy used in farm production in terms of litres of gasoline:

1. It takes 219 GJ to manufacture a 52 kW (70 HP) tractor. How many litres of gasoline would this be?

2. Nitrogen (N) is an element required for plant growth. Ammonium nitrate (33% N) is a common chemical fertilizer. 1 t of ammonium nitrate requires 30 GJ. How many litres of gasoline would this be?

3.78 kg of nitrogen are required to grow 1 ha of cabbage. How many kilograms of ammonium nitrate are required? How many litres of gasoline does this represent?

4. Atrazine is a herbicide used to stop weed growth in corn fields. 4.5 kg of atrazine are usually required per hectare. 202 MJ are required to manufacture 1 kg of atrazine. How many litres of gasoline would this represent? How many joules is this?

Table 5.3

Food (Output) Energy Versus Input Energy

Year	Ontario grain corn yield	Food (output) energy	Input energy
1945	1143 kg/ha	41.2 GJ/ha	9.6 GJ/ha
1975	2337 kg/ha	84.1 GJ/ha	30.0 GJ/ha

Food (Output) Energy Versus Input Energy

★The total amount of food energy produced per hectare of corn has more than doubled since 1945. Complete table 5.4 using the figures in table 5.3.

Table 5.4

Year	Food (output) energy ÷ input energy
1945	
1975	

★What has happened to the *energy* efficiency of corn growing in Ontario? Has it increased or decreased?

Although yields are much higher than in 1945, the amount of energy spent to grow corn has increased even more than have the yields. Today, we use more fertilizers and pesticides. Most of the corn is dried in large natural-gas driers rather than in wire-covered cribs (where Mother Nature would dry it).

★If we examine the energy efficiency of various foods (at the farm level only – i.e., not including processing and cooking), we see that some types of foods are better than others. In general, grain products are best, fruits and vegetables are second best, and meat products are the least efficient. Calculate the ratio of food (output) energy to input energy for corn.

For each unit of energy input to the following food products, we can expect approximately the following units of food energy output:

Table 5.5

Crop	Food (Output) Energy	Input Energy
Soybeans	5.7 GJ/ha	1 GJ/ha
Wheat	3.8 GJ/ha	1 GJ/ha
Carrots	3.7 GJ/ha	1 GJ/ha
Apples	2.1 GJ/ha	1 GJ/ha
Milk	0.7 GJ/ha	1 GJ/ha
Eggs	0.5 GJ/ha	1 GJ/ha
Beef	0.3 GJ/ha	1 GJ/ha

Improving Energy Use on the Farm

Animal manure is often called waste, but it isn't – it's a valuable resource. Plants require nitrogen (N), phosphate (P_2O_5), and potash (K_2O) to grow, and manure contains all three. From an energy standpoint, nitrogen is the most important element contained in manure. 1 t of manure contains about 5 kg of nitrogen.

★How many tonnes of manure are required to supply the nitrogen to grow 1 ha of cabbage?

★How much energy per hectare can be saved by using manure rather than by manufacturing ammonium nitrate?

By using animal manure effectively, we can reduce energy consumption and pollution. Application rates of 11–22 kg of manure per hectare are not uncommon.

★If the equivalent energy of the manure produced by the dairy cow, egg layer, and beef steer is considered along with their food energy, then their energy efficiency increases dramatically – in some cases by more than 100%. Can you think of another source of manure other than Ontario farms?

We can also improve energy use on the farm by using plants that are more productive (i.e., that require less input energy and yield more food energy). Agricultural scientists are now working on this problem.

Our Diet – Energy Plus

Food energy is an important part of our diet, but it's not the whole story. We also require proteins, vitamins, minerals, and water. As we have seen, grain corn provides 2.81 units of food energy for every unit of input energy on the farm. However, very few of us eat whole-grain corn or even corn flour. Once the corn is shipped and manufactured into corn flakes or corn oil, the energy efficiency decreases because energy is required for processing and distribution. Whole grains and fresh fruit and vegetables require very little processing and are very energy efficient. Other foods such as TV dinners, potato chips, and meat must be processed, packaged, and refrigerated (in some cases) and are very energy inefficient.

We could save a great deal of energy by switching to soybeans for our protein, but we must be careful – soybeans don't contain all the types of protein necessary for human nutrition. Thus, we would still require more than one protein source. Meat, milk, and eggs do contain all the necessary proteins. A balanced diet is essential. You should use your library to refer to textbooks on nutrition that outline balanced diets, including some that show how to obtain a balanced diet from plants alone.

The Great Canadian Land Myth

It has often been said that Canadians will never have to worry about food – we have lots of land. There are two things wrong with that statement:

1. We don't have lots of *arable* land (i.e., land suitable for growing crops).

2. It takes land *and energy* to grow food. Our food system operates with a very substantial energy subsidy.

★Canada's area is 9 980 567 km². The area of the United States is 7 707 692 km² (not including Alaska). Complete the following table:

Table 5.6

Country	Area total	% Arable	Total hectares of arable land
Canada		3.9	
United States		23.5	

A great deal of our arable land is in the Prairies – more than 300 km north of the line of latitude that passes through Sudbury. This land is unsuitable for fruit crops and grain corn because of severe winters, a short growing season, and insufficient precipitation. Small grains (wheat, barley, oats) are the main crops grown in the Prairies, and Canada actually produces more of these crops than she can consume. Consequently, these crops are very important to Canada from a world-trade standpoint (although our shipments are very small compared to those of the United States). However, Canada is a net importer of most fruits and vegetables, and there are few areas in Canada that are suited to these crops.

How Productive Is Our Land?

The human body requires 45 to 60 g of protein and 7.5 MJ to 12.6 MJ of food energy daily. We can use 1 ha of land for many food products, e.g., we can grow hay for dairy cattle which give us milk or we can grow carrots. It has been calculated that 1 ha of land used for dairy production will provide one person with a 583-day supply of protein (60 g/d).

★Using the daily human-protein and energy requirements, complete the following table:

Table 5.7

Crop	Digestible protein per hectare	Number of days supply of protein	Energy per hectare	Number of days supply of energy
Soybeans	602 g		15.1 GJ	
Wheat	258 g		17.5 GJ	
Carrots	625 g		44.7 GJ	
Apples	440 g		24.2 GJ	

If our population continues to grow rapidly, if we continue to waste energy, and if we continue to build houses and roads on agricultural land, we will be forced to consume food products that are more energy and land efficient (i.e., less meat and more cereals).

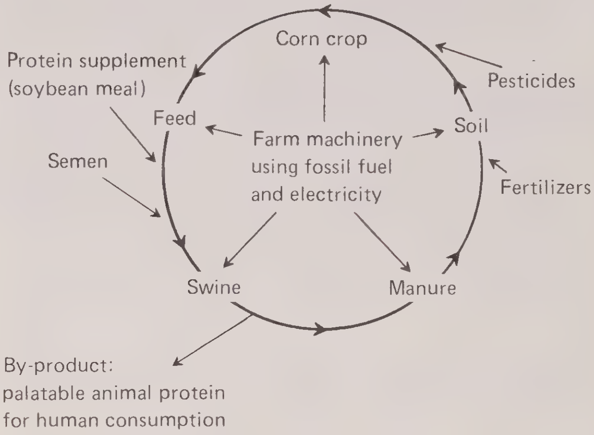
Factory-Feed Controlled Environment

★In our search for higher productivity from the soil, we have found that one of the most efficient feed-energy conversions from plant to animal takes place in a factory-feed controlled environment on the farm. Support this statement with reasons.

Another method of feed-energy conversions is the cycle approach. In this case, specialized crops and supplements are fed to specific livestock in a controlled environment. The operator tries to minimize his inputs (costs) and maximize his outputs. If he is able to organize his operation so that the system is capable of generating its own energy (inputs) to keep it going, it is called a closed system.

Figure 5.3

Cycle Approach – A Nearly Closed System of Farm Feeding


Corn crop
Protein supplement (soybean meal)
Pesticides
Feed
Farm machinery using fossil fuel and electricity
Soil
Semen
Fertilizers
Swine
Manure
By-product: palatable animal protein for human consumption

★1. What keeps the system going?

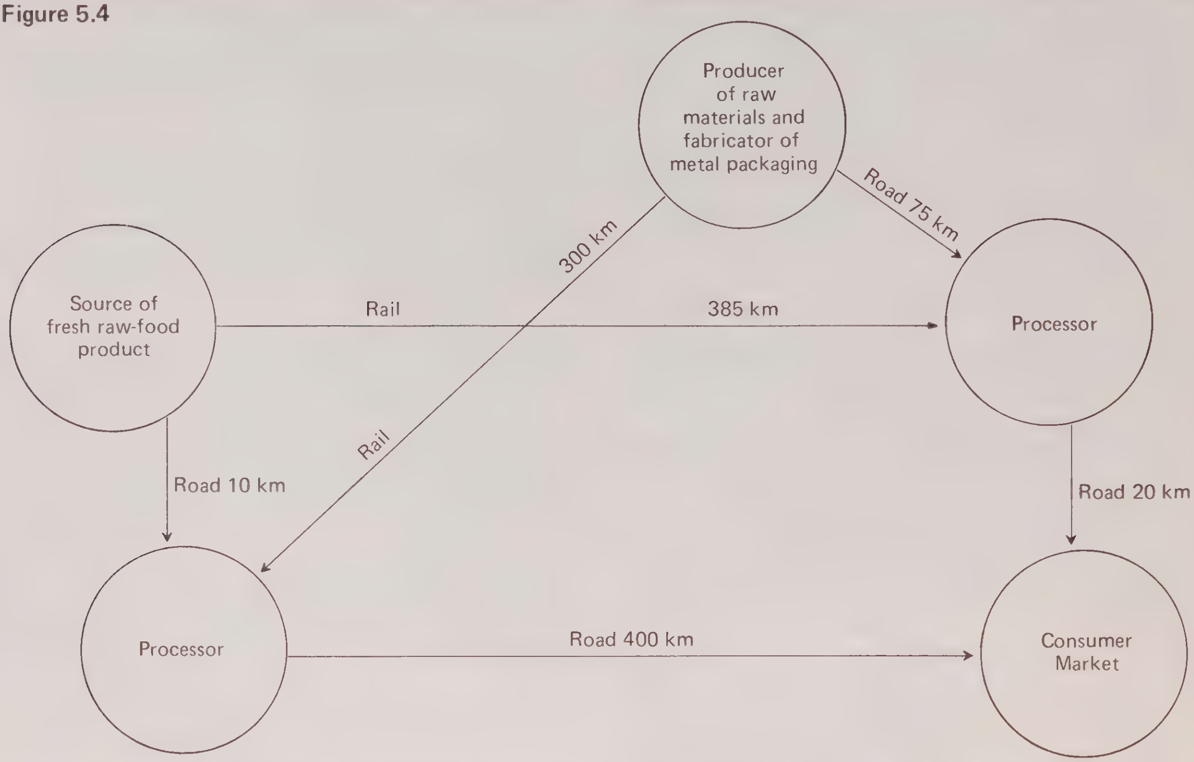
★2. What unit(s) must be constantly fed into the system to keep it operating?

★3. If the inputs are withdrawn, the simple ecosystem is vulnerable to breakdown. List the inputs in order of most-to-least damaging to the system and give your reasons.

★4. What by-products are produced by the non-renewable resources the farmer uses in the simple ecosystem. Of all the inputs to the cycle, which is the most costly non-renewable resource?

In our attempt to gain greater productivity from the soil, we have located specific climate and soil environments that are best suited for certain crops. In some cases, processing plants have been located at or near the source of the raw product. In other cases, the raw product must be transported to a distant city for processing. In both cases, transportation is an essential energy consumer which adds to the cost of the product. Figure 5.4 graphically illustrates this problem.

Figure 5.4



★ As more data in terms of energy equivalents become available, you might compare the cost of shipping a certain quantity of a particular raw-food product to a processor-packager located near the consumer market to one located near the source of the raw product. Take into consideration that there may be loss through spoilage during the transport of the fresh vegetable or fruit. Remember also to depreciate the cost of the machinery involved.

Transportation of the Raw Product

Grain is shipped by rail from the Winnipeg elevators to Thunder Bay, where it is transported by lake freighters to Toronto. Find the energy equivalent of diesel fuel expended to move 500 kt (kilotonnes) from Winnipeg to Toronto by using the following data:

Rail (including depreciation) = 360 (kJ/t)/km
Water (including depreciation) = 300 (kJ/t)/km
Truck (including depreciation) = 770 (kJ/t)/km

The maximum payload capacity for each type of transport is:

Railway freight car = 110 m^3
Great Lakes freighter = 18 200 m^3
Truck = 36 t (tonnes)

★ There are 36.74 bushels of wheat per tonne. What is the energy equivalent in gigajoules per tonne per kilometre? Diesel fuel = 38.4 MJ/L (1 L costs 17¢). How much more would it cost in gigajoules per tonne per kilometre to transport it by "rail" only?

Food Processing, Packaging, and Storing

For this activity, energy-expenditure equivalents are not available at this time. However, you should recognize that increases in costs reflect increased expenditures of energy.

★ Keep an account of the amount of fruit juice your family consumes in a week and in a month. Calculate the total cost in dollars spent. From the data in table 5.8, calculate the cost of the raw product and the cost of waste (packaging).

Table 5.8

Cost Breakdown of Fruit Juice

Per cent	Items
16	raw ingredients
2	washing
30	packaging — paper, metal, glass
5	labour
9	freight (a Canada average)
10	marketing
20	fixed costs — salaries, research, engineering, administrative, corporate donations
4	corporate taxes
1	dividend to shareholders
3	for expansion of industry

★Suppose you bought a tonne of apples and processed your own apple juice. Is there a saving if you include your own labour? When energy equivalents become available for processing and packaging, you might calculate the savings in megajoules per litre.

Each fruit, vegetable, cereal, and meat has its unique harvesting, processing, and storage methods. Some products are more consumer-intensive (have higher consumer demand) than others for various reasons: palatability, cost, nutritional value, preservation needs, versatility in cooking, and convenience.

The kind and quantity of a product that ultimately finds its way to the processor-packager depend not only on consumer preferences but on the availability and preservation qualities of the raw-food product.

Microbial action, whose growth is complemented by certain environmental conditions, ultimately deteriorates all raw-food products. The keeping quality of a raw food is indirectly related to its percentage of water content. Processors employ research and technical staff to ensure that each crop is harvested and processed at the right time to ensure that a quality product is produced.

★1. Calculate the cost of canning a large quantity of a particular fruit or vegetable yourself and compare your cost to the shelf cost of a similar product in the grocery store.

★2. Make a list of the various ways you could process and store food at home. Once you understand how it is done, you can buy "in-season" fruit and vegetables and other food products in bulk at a cheaper price. Many health-food stores, farmers' markets, and small independent grocers sell food in bulk. Calculate the difference in cost of certain items when purchased in bulk (50 kg of potatoes, apples, beef, sugar, flour, etc.) and when purchased in the present standardized convenience packages.

★3. The advertising industry generates great interest in competitive packaging. Furthermore, changes in government regulations necessitate changes in advertising and packaging. What are some of the recent changes you have noticed in the advertising and packaging of the products you purchase ? Are they easier to compare on a mass basis? Remember that energy is consumed and evaluated in terms of cost every time there is a packaging change for a particular product.

★4. How many companies are producing the same food items? Are they all packaged according to the same sizes, masses, and energy per nutritive value? Are the package data listed in the same way in each case? Is the price the same? Why does the grocer advertise "loss-leaders" and specials?

★5. Some packaging is necessary and serves a useful function to protect the food products during transport. However, the merchandiser often has other motives in mind, when deciding on packaging for specific products. What are these motives? Are they worth the extra cost to you when you buy the product?

★6. The Ontario Ministry of the Environment, through its recent legislation, is moving towards the phasing out of non-refillable soft drink bottles. What were the factors the Ministry's task-force may have considered in recommending a return to refillable containers?

★7. If you were placed in charge of packaging various food items, what basic information would you have to consider in making your selection for the product data on the label, the packaging size and material, and the handling and storage needs?

★8. Find out why some farmers store their harvest, e.g., grain, apples, potatoes. Each crop requires a special kind of environment. List the various factors that you have to consider to prevent storage loss.

★9. If you live near grain elevators or a flour mill, investigate these storage facilities. What is the cost for storage that must be added to the final cost of the product? How much energy is expended to dry and store a tonne of grain for five months? If you live in a fruit and vegetable region, you might investigate the amount of electrical energy required to store a tonne of your favourite fruit or vegetable for a specified period.

★10. Set up an experiment to determine the most effective, commercial packaging material for freezing a specific food at home. Research like this adds to the cost of the product.

★11. From the appendix, pp.31-41, "Nutrient Value of Some Common Foods", make a selection of the best energy/nutritive foods for your favourite breakfast, lunch, and dinner for a family of five, including two adults and three teen-agers. If you are unable to buy the food items to complete this activity, you can check the relative costs of purchasing the products in their various forms and enter them in a chart like table 5.9. Calculate the unit price for each food item under each category – fresh, frozen, and packaged foods. Tally columns 1, 2, and 3. Is there a difference in the cost of each? How much will the cost change when the energy expenditure for food preparation and cooking is included. Discuss your results.

Note: To find the food value in kilojoules, multiply the value given in calories by 4.2. For example,
200 cal = 200 x 4.2 kJ
= 840 kJ

Food Preparation

★Calculate the amount of electrical (gas) energy used in your home for one week in food preparation and the amount of energy expended by the person or people preparing the meals. (For your calculations, assume that the energy expenditure in the work of preparing the meals is 18.8 kJ/min.)

Can We Save Energy and Still Cook Our Food?

Energy in the form of gas or electricity can be saved by using appropriate cooking utensils and by selecting a suitable cooking temperature.

★Try the experiment outlined in table 5.10 with the variations suggested to find the best combination when cooking food. Calculate the energy required in each case to bring the water to a boil. It is important that the same type of metal pot be used throughout.

★Compare your results with the class. What is this method of heat transfer called?

Do Some Types of Cooking Equipment Save More Energy Than Others?

You have probably seen skillets that have bottoms made from iron, aluminum, glass, pyroceram, stainless steel, tin and copper. Design an experiment to find the order of heat conductivity of the various materials. The only variable in your experiment should be the different kinds of similar-size skillets. Why do we have so many different materials in our cooking equipment?

Table 5.9

Selected food items	Food Energy in kilojoules	Fresh produce			Frozen			Packaged — Metal — Paper		
		Quantity	Purchasing price	Serving price	Quantity	Purchasing price	Serving price	Quantity	Purchasing price	Serving price
Total										
Column				1			2			3

Table 5.10

Trials	Same metal			Lid off	Burner setting			Volume of water	Record the time it took the water to boil
	Large pot	Small pot	Lid on tight		High	Medium	Low		
1	X		X			X		1 L	
2		X	X			X		1 L	
3	X			X		X		1 L	
4	X		X		X			1 L	
5	X		X				X	1 L	

Does a Pressure Cooker Save Energy?

★Examine how a pressure cooker operates. Select a similar-size cooking pot with a lid. Add the same amount of water and vegetable to the pot and the pressure cooker. Set each on a burner of the same size at the same temperature and record the time taken by each to cook the vegetable properly. (You will have to check the instructions for the pressure cooker to know when the particular vegetable is cooked.)

Note: Why should the pressure cooker be either cooled in water or allowed to stand before being opened?

★Satisfy yourself that the vegetable is properly cooked. How does the cooking time of the pressure cooker compare with that of the regular pot and lid?

★Is there any energy saved by using the pressure cooker? Why don't more families use this equipment? What are its limitations in food preparation?

★Water or Cooking Oil?

Cooking oils and water are most widely used in food preparation. Design an experiment by which you can determine whether oil or water requires less heat to boil potatoes. All variables should be kept constant. Use the same mass of oil and water. Be careful with the oil.

Which liquid boiled first? Which liquid retained its heat the longest after removing the heat source?

★Surface Area to Mass Ratio

The transfer of energy by conduction is only as effective as the ratio of the surface area to the mass. Can you prove this?

Cheating the Oven in Baking a Cake

★Many cake mixes or recipes require the oven to be preheated to a designated temperature before the ingredients are placed in the oven. According to the manufacturer of the cake mixes, this is essential to obtain a quality product. Can you suggest uses for the oven in preparing a meal when it is being preheated for baking?

★ Select an oven with a window for this experiment. Place a thermometer in the oven so you can see it. Turn the oven to the selected temperature for a particular cake, e.g., 175°C. Preheat the oven. Design a graph to record the temperature against the time to reach 175°C. Watch the oven light which indicates when the oven comes on and goes off. Record the temperature and the time each time the light goes off and comes on until the cake has been baked. From your observations, how much sooner could the energy be shut off compared to the length of time suggested on the cake-mix package to get a quality product?

★Select and prepare your favourite cake mix. Set the timer and the oven for the time and temperature required to bake the cake. Put the cake mix in the oven without preheating. When the timer rings, shut off the oven. Leave the cake in the oven for the period required to preheat the oven. How did the cake taste? Did you save some energy?

If the results of the experiment are not acceptable, you could save electrical (gas) energy by shopping for cake mixes and other foods that require a lower preheating oven temperature and less time to bake or cook the product.

★**The More You Bake the Cheaper It Is!**
Bake a loaf of bread in the oven. Record the number of times the oven light goes on and the time required to bake the bread. Now place four loaves of bread in the oven and record the frequency with which the light goes on and the time required to bake the four loaves. Compare the energy required to bake a loaf of bread by each operation. What conclusion can you draw from this experiment?

★ **Cooking Habits Are Difficult to Change!**
Record your family's cooking habits for a week. What suggestions do you have for them. Compare your family's cooking habits – the number of burners that were used, for how long, and at what temperature – with families of other classmates. Don't forget snack preparations.

★ **Give Your Refrigerator a Break!**
Every time you place a food product in the refrigerator, unless it is frozen, energy is required to take the heat out of the product until it reaches the set temperature. Examine all the products in your refrigerator and try to find an alternative spot for each product in case the electricity or gas is shut off.

★ Do all the products have to be stored in the refrigerator until they are used? Remove parts of each product – e.g., an egg, some honey, jam, meat, a vegetable, or a fruit. Store these parts in different places and compare their keeping quality with those in the refrigerator at the time you would use them. What are your conclusions?

★Check the present setting of your refrigerator. Turn it to the next warmer setting and observe, over the period of a week, the keeping quality of the food at the time of use. If there is no spoilage, set the indicator to the next warmer setting. Keep doing this until you find the lowest setting at which the food keeps. Is the refrigerator getting a rest?

★ Each time the refrigerator door is opened the cold air spills out and warm air enters. This causes the compressor to use energy. Stick a tally sheet on the refrigerator door, and request that for one week it be initialed by the user each time the door is opened. The purpose for opening the door each time should also be noted. Analyse the results and see if you can organize the food preparation and snack time in such a way that it reduces the work load of the refrigerator.

★ Many families have a deep-freeze. Some are placed in the basement while others are found in a garage. Find out which requires less energy.

★ **Other Ideas for Cheating the Stove**
Now that you have learned how to store and prepare food more efficiently, calculate how much electrical (gas) energy is used in your home for another week in food preparation. How much energy could you save by the discoveries you have made? Consider both the electrical (gas) and human energy involved?

★ How could you reduce the cooking period of large bulk products, such as potatoes, beets, and apples?

★ It requires a great deal of planning to produce an enjoyable, nutritious meal. Although it is traditional during the colder part of the year to offer a hot meal, could you persuade your family to have one cold meal during the week as a method of saving energy?

Remember to try the "one-pot" meal once per week. It's a great-energy saver!

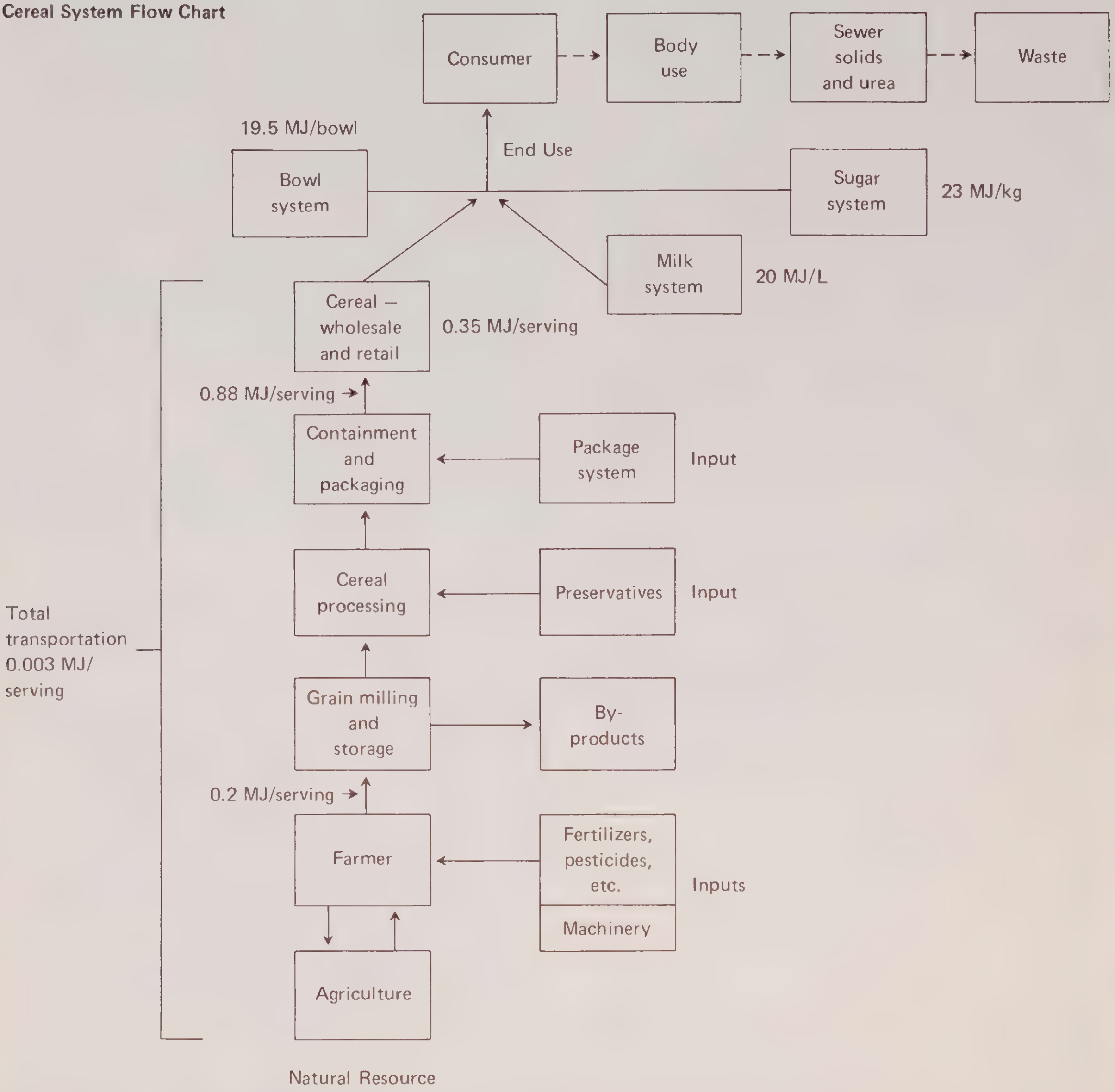
Energy Accounting Through the Materials-Flow System

A materials-flow system traces the services and/or the various flows of all required commodities from their natural state as a resource to their produced and packaged forms at the point of consumption: for example, from a cereal grain to a box of breakfast cereal or from an apple to a glass of apple juice. At every point along the way, physical energy (sometimes referred to as "cultural energy") is expended in order to proceed to the next stage or process. To ensure an all-inclusive, accurate physical-energy accounting for a specified commodity, the analyst develops a flow chart (figure 5.5). The chart begins with a "starting point" – usually a natural resource – and an "end point" – the point of consumption. For each materials-flow system, the energy analyst may specify the parameters of his accounting system. This accounting for business purposes is usually done in the accepted currency of the country. Since the monetary system periodically fluctuates, it is not a true value of the physical-energy expenditure. No matter what the dollar value might be, the physical-energy expenditures to produce a specified commodity remain the same. For this reason, the energy analyst prefers to equate the physical-energy expenditures in terms of an energy equivalent that will remain constant, i.e., the energy that is found in a litre of gasoline of a specified octane rating.

In order to determine the physical energy expended by a particular processor, packager, or transporter to produce the various intermediate materials that go into the delivery of the final end-use product, the analyst must consider various factors, such as the cost and depreciation of machinery and plant buildings and the cost of insurance, electrical and fossil-fuel energy, labour, materials, chemicals, labelling, advertising, and transportation. Each of these cost factors must be apportioned to the production of each product unit or service. Then, each

Figure 5.5

Cereal System Flow Chart



product or service entered on the chart must be traced from its end use back to its natural resource; for the sake of accuracy and consistency, all of these calculations must be carried out to cover the same time period.

An energy analyst, therefore, begins with a definition of an end-use consumption of goods and services that must be detailed and equated in terms of recognized SI energy units.

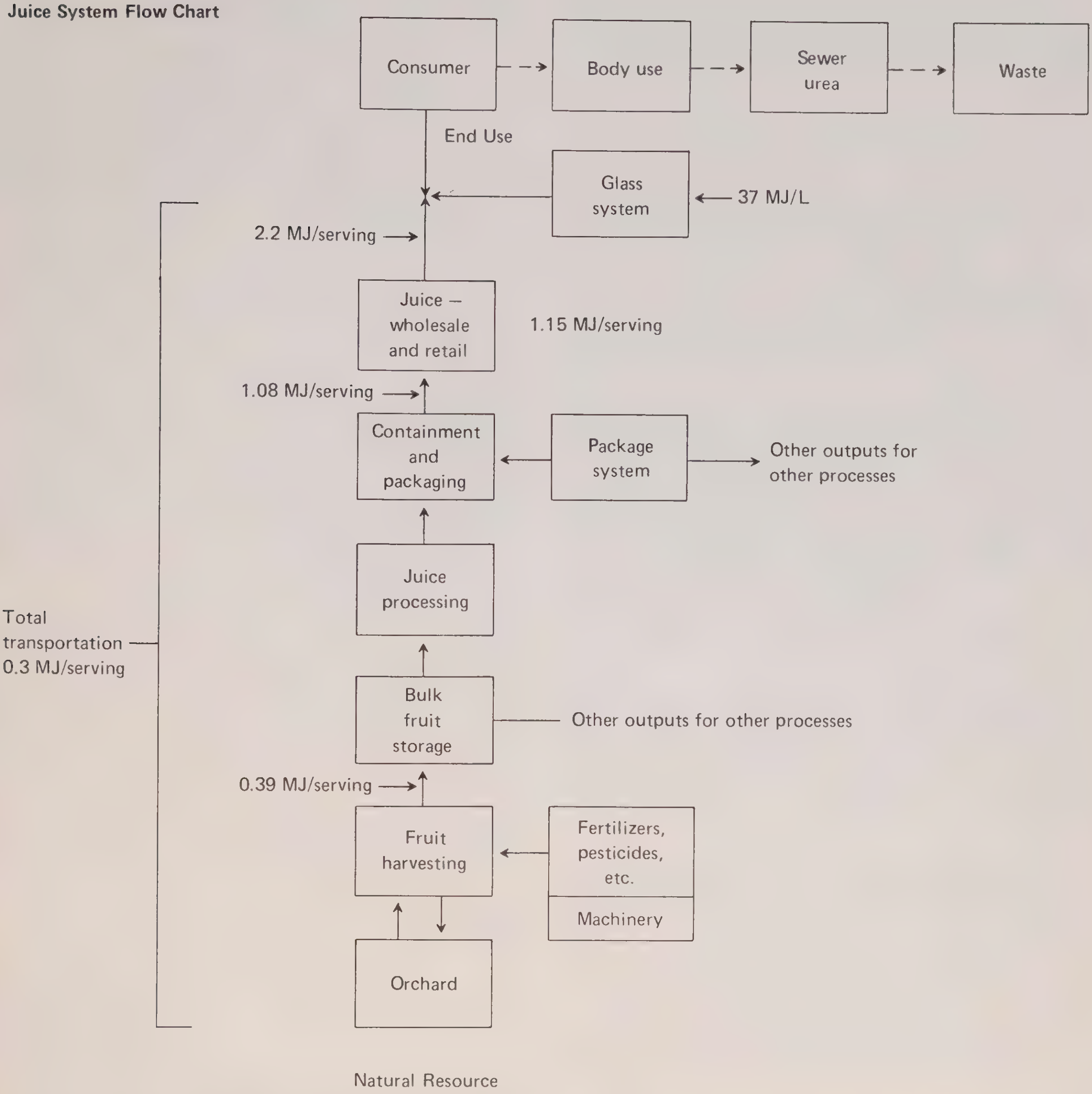
Physical-energy-expenditure tables have been produced by various sources for the production of materials and services that are available for use in a materials-flow-system accounting. A word of caution here: select the data from reliable sources. This area of research is relatively recent, and a survey of the data indicates some disagreement in the assigned values for various energy expenditures.

Besides the physical energies that we expend to produce food products, these products also contain an inherent nutritive energy. The food energy ratings found in nutritional tables represents the optimal potential energy that may be converted to useful chemical energy by the body.

This nutritional energy is not calculated in the energy analysis of the materials-flow system. It is assumed that in paying for the physical energy of the materials-flow system, the consumer pays for the inherent food energy. It could be considered a "double accounting" if both types of energy were included in the energy-expenditure calculation.

Figure 5.6

Juice System Flow Chart



Energy Analysis of Two Materials-Flow Systems: Breakfast Cereal and Fruit Juice

In this study, the end use is defined for two products – a breakfast cereal and a fruit juice.

Cereal

The delivery to the consumer of one average serving (0.043 kg) of an average dry breakfast cereal (wheat, corn, or oats) along with 0.15 L milk and 0.014 kg sugar (refined).

Fruit juice

The delivery to the consumer of one average serving (0.24 L) of fruit juice.

Examine the materials-flow charts.

The *bowl system* represents all stages (an entire system) in the manufacturing, transporting, and processing of an average 0.23 kg ceramic bowl to the consumer. (Note: The "spoon" is not included, as its likely energy contribution is even smaller than the bowl's.)

The *milk system* represents all stages in the delivery of 0.15 L of milk to the consumer.

The *sugar system* similarly deals with the delivery of 0.014 kg of sugar to the consumer.

The *glass system* deals with the delivery of one average drinking glass to the consumer.

These four systems are included in the analysis to show their energy contribution to the total compared to the energy contribution from the cereal or juice flow itself. One of the prime tasks of the energy analyst is to decide (sometimes in advance) whether it is worth while to include certain systems and to exclude others.

What other systems could have been included in these flow charts (e.g., "spoon" has already been mentioned)?

At the time of preparing this section, there were no individual energy-expenditure figures available for the storing, processing, and packaging of these products. How would you find the collective energy expenditure for these items per serving?

★List the number of different energy inputs that you know are required at the following stages of the materials-flow system: (1) the farming, milling, and processing stages of cereal production; and (2) the harvesting, processing, and retailing of fruit-juice production.

It should be noted that there are material flows to systems other than the one under consideration from almost every process box on the flow chart. Consider "bulk fruit storage" in the juice system. The fruit picked from the tree does not only go to juice processors; it also goes to canned- and whole-fruit systems, candy systems, liqueur systems, and is exported. Along with the product of interest, these are called *co-products* of the process. What are other co-products of these systems?

★1. When the energy analyst knows how much prime energy is put *into* a process, he or she must apportion this energy among the co-products, usually according to their mass. What other ways are there to apportion this energy?

★2. The two flow charts contain representative cumulative energy values for each process box depicted, thus including all those that have preceded it. These are the energies expended by humans and do *not* represent the nutritional energy inherent in the goods (food products) themselves. How can we release this inherent energy in the goods?

★3. Cereal system: If 0.88 MJ has been expended up to and including "containment and packaging" and 0.2 MJ expended up to and including "farmer", how much energy has been expended for (a) "grain milling and storage", (b) "cereal processing", and (c) "containment and packaging"?

★4. Juice system: If 2.2 MJ represents the energy expended to make 0.24 L of juice available to the consumer, 9 MJ are required to make and bring the glass to the consumer's table, and 0.3 MJ have been expended on transportation, what has been the total energy expended to put the glass of juice on the table?

★5. Cereal system: What has been the total energy expended to serve a family of five one meal of cereal in bowls with milk and sugar?

★6. Cereal system: What has been the total energy expended to enable one person to eat cereal for 5 d? (Here we need five helpings each of cereal, milk, and sugar, but the same bowl is used each time.)

★7. What is the energy difference between feeding five people one breakfast and one person five breakfasts?

★8. What has been the total energy expended for both systems to enable one person to eat cereal and juice for 5 d?

Answers

1. Dollar value, volume, "value" to society, etc.

2. Burning, chemical reactions, eating, etc.

3. 0.88 - 0.2 MJ/serving = 0.68 MJ/serving.

4. (9 + 0.3 + 2.2) MJ/serving = 11.5 MJ/serving

5. 5 x (19.5 + 1.23 + 0.003 + 2.95 + 0.32) MJ/serving = 120 MJ for five servings (each person needs one each of milk, sugar, cereal, and bowl).

6. [5 x (1.23 + 0.003 + 0.32 + 2.95) + 19.5] MJ/5 d = 42 MJ.

7. (120 - 42) MJ = 78 MJ.

8. [5 x (1.23 + 0.003 + 0.32 + 2.95 + 2.2 + 0.3) + 9 + 19.5] MJ = 63.5 MJ.

Detailed Calculations for the Materials-Flow Charts (for Teachers' Reference)

★For further explanation, obtain the references listed on page 23.

Bowl System

Fritsch and Casselman, in *Lifestyle Index,* p. 24, give figures for making and merchandizing pottery, earthenware, and china in the United States in 1970-71:

5 Energy Units (E.U.) per capita x 34 300 BTU/E.U. = 171 500 BTU per capita.

Assume that one bowl represents $^{1}/_{40}$ of a complete household stock of pottery by mass (weight) and 4.3 persons per household gives:

171 500 BTU/per capita = 4.3 persons/household x $^{1}/_{40}$ household x 1055.06 J/BTU = 19.5 MJ/bowl.

Milk System

Middleton Associates, in *An Adaptation of Albert Fritsch's "Lifestyle Index",* p. 8, give the following 1972 figures for milk and cheese for Canada:

Production and processing – 58 E.U./per capita
Wholesale and retail – 6 E.U./per capita

Home-consumed milk is in a 15-to-1 ratio (mass) to cheese.

Milk production and processing	54.0 E.U./per capita
Wholesale and retail	5.6 E.U./per capita
	59.6 E.U./per capita

and this represents 2470 MJ/per capita.

The Ministry of the Environment, in the *General Report of the Solid Waste Task Force,* p. 155, Table VI.1.1, gives the average Ontario milk consumption per capita as 97.1 quarts per capita for 1972 or 110.35 L per capita.

Combining this with the required 0.15 L for breakfast:

0.15 L x $(^1/_{110.35})$ per capita/L x 2170 MJ/per capita = 2.95 MJ/serving.

Sugar System
Middleton Associates, in *An Adaptation of Albert Fritsch's "Lifestyle Index"*, p. 8, give figures for sugars and syrups (here assumed to be equivalent to each other in use):

Production and processing	17 E.U./per capita
Wholesale and retail	12 E.U./per capita
	29 E.U./per capita or 1050 MJ/per capita

Albert Fritsch and B. I. Casselman, in *Lifestyle Index*, p. 71, give the 1973 United States refined sugar consumption as 102.1 lb/per capita (46.3 kg/per capita). Assuming the same Canadian unit consumption:

1050 GJ/per capita x 1/46.3 per capita/kg x 0.014 kg/serving = 0.32 MJ/serving.

Glass System
The General Report of the Solid Waste Task Force to the Ministry of the Environment (Ontario), p. 122, gives table V3.7 for 1973:

8316 BTU/glass bottle refillable or approximately 8.14 MJ/glass.

Adding another 500 BTU for transport to the consumer gives 9 MJ/glass.

Juice System
Albert Fritsch et al, in *Energy and Food,* p. 41, give a total of 4000 BTU/lb. for canned juices, or, for a 0.24 L serving, assuming a relative density of 1: an equivalent total of 2.23 MJ/0.24 L per serving.

Fritsch and Casselman, in *Lifestyle Index,* give the following figures for canned and frozen food in the United States in 1973:

Production and processing	28 E.U./per capita
Wholesale and retail	30 E.U./per capita

Pro-rating 2.23 MJ/serving according to the above, we see that:

Production and processing	1.08 MJ/serving
Wholesale and retail	1.15 MJ/serving
Total (no freight)	2.23 MJ/serving

Cereal System
Middleton Associates, in *An Adaptation of Albert Fritsch's "Lifestyle Index"*, p. 8, give the following 1972 figures for cereal and bakery products:

Production and processing	43 E.U./per capita
Wholesale and retail	17 E.U./per capita
	60 E.U./per capita or 2171 MJ/per capita

Albert Fritsch et al, in *Energy and Food,* p. 69, give the 1973 United States per capita consumption of oats, wheat, and corn cereals as 8.4 lb. (assumed the same in Canada). Thus, at 0.043 kg/serving and since cereal represents $\simeq 1/20$ by weight of the consumption of cereal and bread, we see that:

2171 MJ/per capita x 8.4 lb. x (2.2 kg) x 0.043 kg $x^1/_{20}=$ 86.258 MJ/serving.

Pro-rating this according to data from Middleton Associates above:

Production and processing	0.88 MJ/serving
Wholesale and retail	0.35 MJ/serving
	1.23 MJ/serving (no freight)

Cereal and Juice Transportation

Cereal
Albert Fritsch et al, in *Energy and Food,* p. 45, give the United States average transportation energy as 25 BTU/lb. for a 0.043 kg/serving; adding 25% more for longer Canadian freight distances gives 0.003 MJ/serving.

Juice
Albert Fritsch et al, in *Energy and Food,* p. 41, give the United States average transportation energy as 426 BTU/lb. For a 0.15 L/serving, relative density of 1, and Canadian freight distances (25% more), we get 0.30 MJ/serving.

Harvesting Energy

Cereal
Albert Fritsch et al, in *Energy and Food,* p. 45, show that of the total energy expended, 15% is expended on the farm. Applying this ratio to 1.23 MJ, we get 0.2 MJ/serving.

Juice
Albert Fritsch et al, in *Energy and Food,* p. 41, similarly allow us to calculate 0.39 MJ/serving for juice.

References

1. Fritsch, A. J., and Castleman, B. I. *Lifestyle Index.* Washington, D.C.: Center for Science in the Public Interest, 1974.

2. Middleton Associates. *An Adaptation of Albert Fritsch's "Lifestyle Index" for the Canadian Context.* Toronto: Middleton Associates, 1976.

3. *General Report of the Solid Waste Task Force to the Ministry of the Environment,* Volume III., Toronto: Ministry of the Environment, 1974.

4. Fritsch, A. J., et al. *Energy and Food.* Washington, D.C.: Center for Science in the Public Interest, 1975.

Waste

We are a "disposable" consumer society. When you throw away garbage, you are throwing away energy. Think of the physical-energy expenditures of the mining industry for the metals, the pulp and paper industry for the paper, and the petrochemical industries for the plastics that are used in packaging. Even the storage of this garbage at the dump costs money. If an incinerator is used to dispose of this waste, more energy is consumed.

To get a further understanding of the energy loss in this area and what you can do about it, write to:

100 Ways
Box 3500
Station C
Ottawa, Ontario
K1Y 4G1

This free booklet describes many activities on how to save energy and money by throwing out less and by sorting and packaging our garbage.

Pioneers butchered fattened hogs to feed their families and bragged that, "The only waste in the slaughter was the squeal of the hog, when it was killed." This practice is consistent with today's slaughter-house operation. Visit a meat-processing plant and observe how every part of the animal slaughtered is used in so many ways. There is relatively no waste. Yet our food-waste behaviour, particularly in the urban, fast-paced environment, has labelled us a "disposable consumer society".

Processed food is not the only thing that is wasted. Due to economic problems, large quantities of fruit and vegetables are never harvested. Insects, fungi, and bacteria, which are parasitic on both plants and animals, rob them of energy and even kill them. Our experimentation with food additives and other chemicals destroys plants and animals and their products. Errors in industrial processes create waste. There are also wastes caused by the plant and animal losses to the elements of nature – fire, hail, frost, drought, and wind storms.

We still appear unconcerned about the waste of energy (fossil fuels) that is used by both trains and trucks that take a load of food to the urban centres and return *empty*. There is also the question of reclaiming the energy in the waste products of animals (manure) and humans (feces). Our relative inability to harness the energy of the winds about our planet, to genetically produce new plants that could be more efficient solar-energy converters, and to capture more of the heat given off by food-processing plants are all potential areas of waste and a challenge for the future.

★ What can you do about it? Here are some activities you might try to get a better understanding of the problems related to waste disposal.

★ Estimates indicate that Ontario farm animals produce approximately 42 000 000 t (tonne) of manure each year. If this were fully reclaimed as plant nutrients and gaseous hydrocarbons, the energy yield would be equivalent to 8 x 4.546 L of gasoline per tonne of manure. Calculate the amount of energy that is available in animal manure. If it were possible to use this energy to produce food, how many people could be fed from the produce?

★ If an urban sewage-treatment plant is unable to properly digest its dangerous heavy metals, the sludge may not be used as a fertilizer for plant growth. The by-products of chemical processes by industries produce pollutants. These heavy metals are dangerous to both plants and animals. Ask your chemistry teacher if you can do a project on the analysis of your local sewage.

★ Take a trip to the local sewage plant. What waste occurs if the sewage is burned off? What is the energy equivalent to process the sewage that is taken to a landfill site in your community? Obtain this information from the engineer in your public utilities commission.

It is difficult to estimate the cost of edible-food waste per household. Conservative figures indicate that it might be between $75 and $125 on the average, depending on the size of family. The main contributors to this cost of waste in order of degree are as follows: protein foods; fresh fruit and vegetables; cereal products (bread, pastry); packaged goods (convenience foods, take-out foods, canned, etc.); fat and oils; dairy products; snack foods.

★ Get permission and support from your family to store and classify all the food waste at your home for a week. Find the mass of each classification and compare your results with those of your classmates. If you knew the total mass used to begin food preparation, you could calculate the percentage lost in waste energy and the cost involved.

★ Make a trench or furrow in your home garden, or the garden plot you have rented from the city, and bury the organic food wastes. Open part of the trench periodically. What have you discovered?

★ Of what value is this addition to your garden's productivity for next year? Can you place an energy value on this? Have you been throwing joules of energy away?

Metal and glass from canned products and synthetics from packaging are not as easily broken down as is organic waste. These materials must be sent to the incinerator or garbage-disposal landfill site for burial. This material has both mass and volume.

★ List the many different ways by which you could reduce both the mass and the volume of your garbage. Convince your family that you are helping to save energy.

★ Find out how the larger hotels, correctional institutions, the army, etc., separate their garbage. Who buys these food wastes? How is it processed?

★ What are your family's habits for discarding food? Classify them into the following groups: bacterial spoilage, desiccation, spillage, tired of eating it, burned, didn't like what was bought, etc. What were the results after a month of checking? What recommendations did you make to your family to save food energy?

★ Energy is required to dispose of the garbage you have placed in your driveway. Estimates for a city of 250 000 people indicate that it costs 45¢ per pick-up each week, at each residential home. Eighteen work crews average 625 pick-ups daily. What is the annual cost for garbage service to such a community? This service only brings the garbage to the landfill site. It costs an additional 76¢ per capita per year to move it from the gate to be buried. What is the total cost of waste disposal?

★ If a crew of three men (a driver and two pick-up men) collect 1.21 man-hour tonnes of waste each hour, how many hours would each crew have to work to collect 325 t in a day? If the crews work an 8 h day, what would the remainder of the time be used for?

★Find out from the driver of the "garbage" truck the average number of gallons of diesel fuel or gasoline the engine consumes in a day, the load capacity, and the number of trips made to the city dump each day. Calculate the fuel consumption per tonne of waste.

★Much of the food energy we eat and eliminate finds its way to our own septic tank or a community sewage-treatment plant. The value of this waste in terms of energy has not yet been estimated. Find the capacity of your community sewage-treatment plant and the cost of sewage treatment per year.

★Record the number of times you flush your toilet in a week. Find the number of gallons of water used in each flush. Then calculate the cost of flushing the toilet for one year. Obtain the water rate from your public utilities commission.

★Carefully calculate the mass of the body's food intake for a specific unit of time, then collect all the solid and liquid waste in a chamber pot. The human body must be well regulated for this exercise. Calculate the ratio of bulk-mass intake to output. How much of the body's mass intake did the body retain? If the digestive system is efficient, there is very little energy nutrient left in the solid waste. What other kind of energy does the body give off to maintain a constant body temperature? This experiment may also be done with cattle.

★60 g of human urea contain 28 g of nitrogen. Calculate the amount of nitrogen your family flushes down the sewer or septic tank in a year. What is the energy loss if urea contains 38.9 MJ/kg, and nitrogen 83.5 MJ/kg?

Figure 5.7

Factorial Estimate of Total Energy Needs

Subject: male Mass: 60 kg Height: 170 cm Age: 35
Basal metabolism: 1 (kJ/kg) / h = 1 kJ x 60 x 24 = 1440 kJ

Activity			
Type of Activity	Time (h)	Energy Expenditures	
		(kJ/kg)/h	kJ/kg
Dressing	1.5	0.166	0.25
Sitting	6.0	0.095	0.571
Skating	0.5	0.833	0.405
Walking (5 km/h)	2.0	0.476	0.952
Standing relaxed	1.0	0.119	0.119
Typing	4.0	0.238	0.952
Sleeping	8.0	–	–
Playing piano	0.5	0.476	0.238
Walking upstairs	4 flights	0.009*	0.033
Walking downstairs	4 flights	0.003*	0.010
Total energy expenditure for activities		2.415	3.53

Energy expenditure of activity 3.53 kJ x 60 = 211.80 kJ
Energy expenditure of basal metabolism = 1440.00 kJ

Total energy expenditure for basal metabolism and activities 1651.80 kJ
Specific dynamic effect (10%) 165.00 kJ

Total energy requirement 1816.80 kJ

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*Allowance per kilogram for ordinary staircase (15 steps), regardless of time.

4. More for Less?

If you wish to become a conserver generation instead of a disposable generation, follow the three R's – reject, reuse, and recycle. Reduce the waste by not throwing away reclaimable energy sources.

★What can we do? Get the support of your family, school, and neighbourhood and try the following:

1. Plant your own fruit and vegetable gardens. Some large cities provide garden plots at a very reasonable rental.

2. Tell your friends to compete in the fall fairs with their home-grown fruit and vegetables.

3. Chop up the plant refuse about the garden and from the table to make a compost pile which can be used as mulch and fertilizer for the garden.

4. If you have pets, feed them the food remains of meals.

5. Go out at harvest time and pick your own bulk fruit and vegetables. Take some friends along and make it a fun day!

6. Provide a storage place in your home to keep fresh fruit and vegetables.

7. Purchase as many food items in bulk as possible, if storage is available to prevent spoilage.

8. Nothing is more expensive than impulse buying. Plan your purchases: make a list for grocery shopping and stick with it! Shop for specials that have high nutritive value.

9. Cut down on the use of meat. Purchase protein foods that are cheaper and have relatively the same nutrient value.

10. Reduce your purchases of convenience foods. They are expensive and you pay more for their packaging.

11. Reduce your consumption of high-energy foods like candy. They are expensive and are lacking in complete nutritive value.

12. Stage a food-preserving bee and can your own fruit and vegetables.

13. Find out what your energy intake should be per day and stick to a proper nutritive diet. Obesity is a form of energy waste.

14. Burn combustibles in your fireplace.

15. Make fire logs out of your newspapers and burn them in your fireplace or sell them to someone who has one.

16. Avoid the purchase of disposable containers, as much as possible.

17. Find alternative uses for disposables and waste-food products, e.g., fat to make soap.

18. Organize the neighbourhood to sort garbage into categories that would complement useful reclamation in your region.

19. Reduce the volume of garbage by crushing containers.

20. Return refillable containers, packaging materials, egg boxes, paper bags, etc., to the grocer, retailer, or wholesaler so that they may be used again.

21. Prevent garden-crop spoilage by employing good cultural practices. Sell or give away excess food from your garden.

22. Are you ready for this one? During the last war, many central Europeans took their human feces and food scraps to their garden plots and buried them to enrich the soil for the next year's crop. There was no commercial fertilizer or animal manure available. Would you do this?

23. Stop smoking tobacco. It is one of the greatest energy expenditures with no nutritive value.

24. Invite friends over and cook "one-pot" meals – set a new trend!

25. Avoid buying overprocessed foods. They are expensive and do not provide the necessary bulk for your digestive system.

26. Plan carefully the purchase and preparation of meals; you can save both electrical (gas) and human energy.

27. Keep a watchful eye on the use of those appliances that consume the most energy in food preparation.

28. Check your electrical (gas) statement each time you receive one. Keep a yearly graph and compare it with that of other class members. At what time of the year is it the highest? The lowest? What is the reason for the fluctuations? What is the cost per capita in your household compared to others?

These are only a few of the ways you might consider reducing waste. The value of trying to become a conserver lies in the deeds themselves. Do yourself a favour and be an energy lifesaver. The life you save may be your own!

5. Suggestions for Further Study

Energy Flow Through a Food-Production System

The energy-analysis flow chart (Figure 5.8) will assist you to calculate the various physical (cultural)-energy expenditures required to produce a certain food product. This type of accounting traces the various flows of physical commodities from their natural state as resources all the way to the point of consumption and/or waste disposal and/or recycling.

At every point along the way, we must expend energy to proceed to the next stage or process. The sum of these individual energies is the total energy expended.

The circles and other pictorial figures in the chart represent changes in physical state; they include the processes that contribute major impacts to the overall physical energy expenditures in the production and delivery of a particular food product for the consumer.

As more data become available through current research activities in the food-production industry, you might select a particular food commodity and trace the various energy expenditures needed to produce it.

★ Compare the physical (cultural) energy (growth) expenditures to the calorie energy (food-rating) inherent in the food for chemical digestion.

★ Calculate, where applicable, the energy-conversion ratios among the first, second, and third trophic (feeding) levels in relation to the selected food product as it moves through the system.

★ What alternatives would you recommend to reduce the stresses placed on the system by the activities indicated in the flow chart?

★ Why is a simple ecosystem considered a "fragile" system compared to a complex one?

Energy Cycles

Rationale

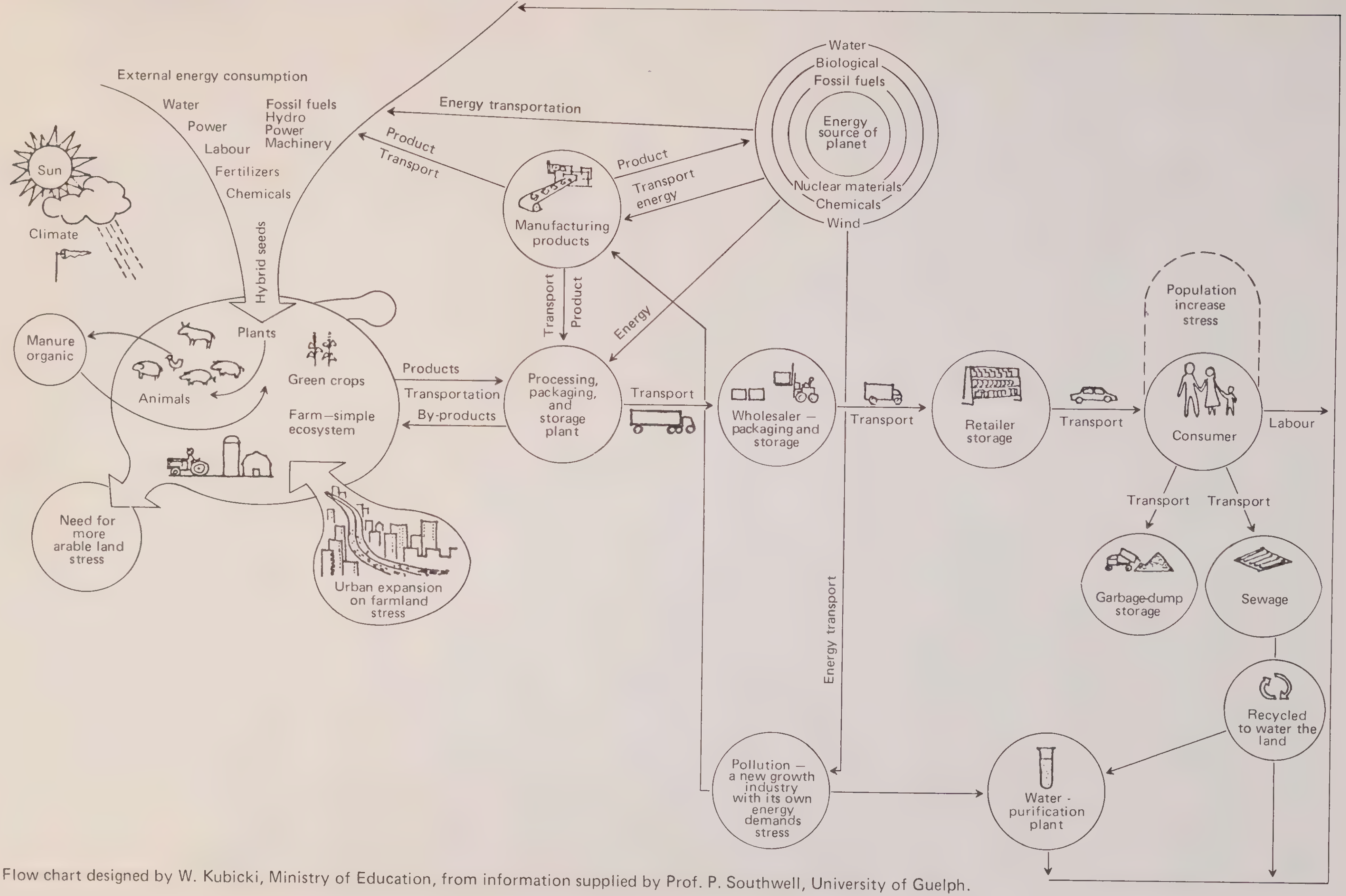
In our search for higher yields per hectare, we have developed one of the most unstable and immature ecosystems on the arable land portions of the world. This could not have been achieved with the local biological energy resources. Tremendous pressure has been brought to bear on particular ecosystems through the importation of power sources. As we continue to force the natural (complex) ecosystem to an artificial, simpler (one crop) one, we lose local autonomy and increase environmental stress. The economy must rely more and more on the importation of energy support systems to drive the unstable ecosystem. The external support systems are often regulated by people and organizations who are unable to grasp, or are disinterested in, the local ecosystem. Hence, the self-regulating capacity of the local ecosystem is diminished and may eventually be destroyed.

Other forms of stress are being felt by the primary food producer. Increased population, urban expansion with its industrial complexes and its necessary life-line services, and pollution control (the new growth industry) are all competing for some form of energy.

Figure 5.8

Energy Flow Through a Simple Ecosystem

Energy use has been a major factor in the supply of food and physical comfort, and in improving the quality of life.



Flow chart designed by W. Kubicki, Ministry of Education, from information supplied by Prof. P. Southwell, University of Guelph.

Our apparent inability to find cheaper substitute products, or to recycle more of the by-products of present-day consumption, or to research other methods of obtaining energy applies further stress on our finite energy resources.

If the arable land is to produce the necessary food energy for an expanded population, priorities may eventually have to be set to ensure that the soil is maintained at its maximum productivity. Ultimately, regulations will dictate the type of crops to be produced for maximum nutritional value.

Objectives

1. To recognize the magnitude of ecological degradation.

2. To identify the variables that are placing a stress on the simple ecosystem.

3. To find ways of reducing energy consumption, while maintaining a satisfactory standard and quality of life.

4. To understand the implications of the change from the low-cost energy of today to the expensive orderly development of the future.

5. To learn that energy management will be forced to plan better utilization of our present energy resources. An effort will have to be made at the political, economic, and technological levels, within a specific time frame, to ensure that sufficient energy is available for future generations.

★ **Strategies**

1. Read articles on energy in newspapers, magazines, and government reports. Identify the issues, debate them, and place your position on each issue on a values continuum.

2. Invite speakers to your class to present various aspects of the current energy and food concerns.

3. View films on the degradation of the ecosystem.

4. Develop a flow chart showing the flow of external energy consumption on a farm.

5. Identify and discuss the factors that are placing stresses on the artificial (farm) ecosystem.

6. Visit a nuclear-power plant to understand its technology and the resulting effects on the surrounding ecosystem.

7. Develop your own energy game. Compare your energy game to commercially developed ones.

8. Write a research report to indicate how energy management should allocate our present energy resources for the benefit of future generations.

9. Recognize that the most efficient energy conversion is from waterfall to mechanical energy to electrical energy. The energy found in fossil and nuclear fuels must first be converted to thermal energy, then converted to mechanical energy, and finally to electric power.

10. Develop a chart showing the flow of energy in the biosphere.

11. Trace the various forms of energy and energy-conversion systems to understand their efficiency and function.

Content Sources

1. energy reports – provincial, federal, and global

2. power stations that are powered by fossil fuels, waterfalls, and nuclear fuels

3. fission and fusion (Nuclear fission takes place in a breeder reactor where excess neutrons from U235 are used to convert U238 and Th232 into Pu239 and U233, which are fissionable isotopes. This form of energy could supply the world's needs for millions of years; thermonuclear fusion is the interaction of light atomic nuclei to produce highly energized new nuclei, particles, and radiation.)

4. mobile energy converters such as power machinery run by steam, gasoline, or diesel fuel

5. energy forms – wind; water; gravity; chemical, solar, nuclear, and fossil fuels; manure; fire; plant material

6. the earth and atmosphere as a heat sink

7. garbage dumps

8. sewage-disposal systems and recycling methods

9. pollution control

10. energy in the natural ecosystem

11. population control

12. standard of living and quality of life

13. energy foods – nutrition

14. processes to utilize various forms of energy

Energy Quiz

★Indicate whether each of the following statements is "true" or "false". The answers are on the next page.

1. A bushel of shelled corn (25 kg) contains more energy than 10.6 L of gasoline. The energy contained in corn is 14.6 MJ/kg.

2. It is more efficient to get protein from milk, cheese, and eggs than from meat.

3. Cheese requires more energy to transport than does beef.

4. The processing of powdered milk requires more energy than does the processing of meat.

5. Protein obtained through milk production requires less energy than protein derived from egg production.

6. Carrot production has the lowest energy-resource depletion for the highest protein and mineral production (23 g of protein per joule of output energy).

7. Nitrogenous fertilizers are the most costly to produce, because they are a renewable resource.

8. Human waste is easier to reclaim than animal manure.

9. In the future, we will have to become more efficient in the reclamation of urban wastes.

10. Chemical input to food production is directly proportional to the availability of fossil fuels.

11. With the depletion of fossil fuels, we will be forced back to subsistence farming.

12. Diesel tractors consume more energy than is contained in the field crops they help to produce.

13. Diesel engines provide about 38% more work per litre of fuel than gasoline engines.

14. Home vegetable gardening requires less labour energy than when the produce is grown commercially.

15. Green plants have a higher efficiency of energy conversion on an output/input relationship than have animals.

Answers to the Energy Quiz
1. True
2. True
3. False
4. True
5. False
6. False
7. False
8. False
9. True
10. False
11. False
12. False
13. True
14. False
15. True

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7. Appendix – The Nutrient Content of Foods

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids			Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
							Saturated (Total)	(Unsaturated)									
								Oleic	Lin-Oleic								
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Almonds	¼ cup	35	5	212	6	19	1	13	4	7	83	1.7	0	0.08	0.33	1.2	0
Apples	1	150	85	70	tr.	tr.	–	–	–	18	8	0.4	50	0.04	0.02	0.1	3
Apple juice, vitamin C added	½ cup	124	88	60	tr.	tr.	–	—	–	15	8	0.8	–	0.01	0.02	0.1	44
Applesauce – sweetened	½ cup	128	76	115	tr.	tr.	–	–	–	30	5	0.6	50	0.02	0.02	tr.	2
– unsweetened	½ cup	122	88	50	tr.	tr.	–	–	–	13	5	0.6	50	0.02	0.01	tr.	1
Apple turnover*	1 medium	84	35	265	2	15	–	–	–	30	16	0.6	–	0.01	0.04	0.3	2
Apricots – raw	3	114	85	55	1	tr.	–	–	–	14	18	0.5	2890	0.03	0.04	0.7	10
– canned	½ cup	128	77	110	1	tr.	–	–	–	28	14	0.4	2255	0.02	0.03	0.4	5
Asparagus, cooked	½ cup	78	94	15	2	tr.	–	–	–	2	15	0.4	655	0.12	0.13	1.0	19
Avocado – California	1	284	74	370	5	37	7	17	5	13	22	1.3	630	0.24	0.43	3.5	30
– Florida	1	454	78	390	4	33	7	15	4	27	30	1.8	880	0.33	0.61	4.9	43
Bacon – side	3 slices	22	8	135	8	12	5	6	2	2	3	0.8	0	0.12	0.08	1.2	0
– Canadian or back	4 slices	84	54	245	23	15	4	8	tr.	11	16	–	0	0.68	0.11	4.4	0
Bananas	1	175	76	100	1	tr.	–	–	–	26	10	0.8	230	0.06	0.07	0.8	12
Beans – common cooked	½ cup	90	69	105	7	tr.	–	–	–	19	45	2.5	0	0.13	0.07	0.7	0
– baked with weiners	½ cup	130	71	182	10	9	–	–	–	16	47	2.4	165	0.09	0.08	1.7	tr.
– baked with pork and tomato sauce	½ cup	128	71	155	8	4	1	1	tr.	25	69	2.3	165	0.10	0.04	0.8	3
– kidney	½ cup	128	76	115	8	tr.	–	–	–	21	37	2.3	5	0.07	0.05	0.8	–
– Lima	½ cup	85	71	95	7	tr.	–	–	–	17	40	2.1	240	0.16	0.09	1.1	15
– snap (green)	½ cup	62	92	15	1	tr.	–	–	–	4	32	0.4	340	0.04	0.06	0.3	8
– yellow	½ cup	62	93	15	1	tr.	–	–	–	3	32	0.4	145	0.04	0.06	0.3	8
Beef, cooked																	
Ground beef, broiled, lean	3 oz.	85	60	185	23	10	5	4	tr.	0	10	3.0	20	0.08	0.20	5.1	–
Ground beef, broiled, regular	3 oz.	85	54	245	21	17	8	8	tr.	0	9	2.7	30	0.07	0.18	4.6	–
Rib roast	3 oz.	85	40	375	17	34	16	15	1	0	8	2.2	70	0.05	0.13	3.1	–
Pot roast	3 oz.	85	53	245	23	16	8	7	tr.	0	10	2.9	30	0.04	0.18	3.5	–
Sirloin steak	3 oz.	85	44	330	20	27	13	12	1	0	9	2.5	50	0.05	0.16	4.0	–
Round steak	3 oz.	85	55	220	24	13	6	6	tr.	0	10	3.0	20	0.07	0.19	4.8	–
Beef and vegetable stew	1 cup	235	82	210	15	10	5	4	tr.	15	28	2.8	2310	0.13	0.17	4.4	15
Beef pot pie	1 pie	227	63	560	23	33	9	20	2	43	32	4.1	1860	0.25	0.27	4.5	7
Beer	12 fl. oz.	360	92	150	1	0	–	–	–	14	18	tr.	–	0.01	0.11	2.2	–
Beets, cooked	½ cup	85	91	28	1	tr.	–	–	–	6	12	0.4	15	0.02	0.04	0.2	5
Biscuits (tea biscuits)	1	28	27	105	2	5	1	2	1	13	34	0.4	tr.	0.06	0.06	0.1	–
Blackberries	¾ cup	108	84	64	2	1	–	–	–	14	34	0.9	217	0.04	0.04	0.4	22

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids Saturated (Total)	Fatty Acids (Unsaturated) Oleic	Fatty Acids (Unsaturated) Lin-Oleic	Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Blueberries	¾ cup	105	83	64	1	1	—	—	—	16	16	1.0	105	0.03	0.06	0.4	15
Bologna	1 oz./2 slices	26	56	80	3	7	—	—	—	tr.	2	0.5	—	0.04	0.06	0.7	—
Bread																	
Raisin (18 slices per loaf)	1 slice	25	35	65	2	tr.	—	—	—	13	18	0.3	0	0.01	0.02	0.2	—
Rye, light	1 slice	30	35	73	3	—	—	—	—	16	22	0.5	0	0.05	0.02	0.4	0
Rye, dark, pumpernickel	1 slice	32	34	79	3	tr.	—	—	—	17	27	0.8	0	0.07	0.04	0.4	0
White, enriched, 24 slices/loaf	1 slice	30	35	82	2	1	—	—	—	15	20	0.5	0	0.07	0.05	0.7	0
Whole wheat	1 slice	30	35	72	3	1	—	—	—	15	15	0.7	0	0.05	0.03	1.0	0
Breakfast cereals — dry, ready-to-eat																	
Bran Flakes, with added nutrients	¾ cup	28	3	104	3	tr.	—	—	—	22	13	4.0	0	0.60	1.00	6.0	0
Cornflakes, added nutrients	1 cup	21	4	80	2	tr.	—	—	—	18	1	3.0	0	0.45	0.75	4.5	0
Cornflakes, presweetened, added nutrients	1 cup	28	2	107	1	tr.	—	—	—	25	1	4.0	0	0.60	0.80	6.0	0
Oats, puffed, with or without corn	1 cup	25	3	100	3	1	—	—	—	25	23	1.0	0	0.02	—	0.5	0
Oats, puffed, presweetened	¾ cup	25	2	107	2	1	—	—	—	25	23	1.0	0	0.03	0.03	0.4	0
Rice, puffed or oven popped with added nutrients	1 cup	28	4	106	2	tr.	—	—	—	24	5	4.0	0	0.60	1.00	6.0	0
Rice, puffed or oven popped, presweetened with added nutrients	1 cup	28	4	120	1	2	—	—	—	24	5	0.7	0	0.60	1.00	6.0	0
Wheat flakes, with added nutrients	1 cup	28	4	105	3	tr.	—	—	—	23	10	4.0	0	0.60	1.00	6.0	0
Wheat puffed, presweetened with added nutrients	1 cup	21	3	80	1	tr.	—	—	—	18	2	0.7	0	0.40	0.75	4.5	0
Wheat, shredded																	
1 biscuit = 12 spoon size	1 biscuit	25	7	80	2	tr.	—	—	—	18	10	0.8	0	0.06	0.02	1.3	0
Wheat, shredded, with added nutrients	⅔ cup	30	35	138	3	tr.	—	—	—	27	16	1.0	0	0.60	1.00	6.0	0
Farina, quick cooking, cooked: enriched	1 cup	245	89	105	3	tr.	—	—	—	21	180	15.5	0	0.05	0.02	0.3	0
Oatmeal or rolled oats, cooked	1 cup	240	87	130	5	2	—	—	—	23	22	1.4	0	0.19	0.05	0.2	0
Broccoli	½ cup	78	91	20	2	tr.	—	—	—	4	68	0.6	1940	0.07	0.15	0.6	70
Brussels sprouts	½ cup	78	88	28	4	tr.	—	—	—	5	25	.8	405	0.06	0.11	0.6	68
Butter	1 pat	5	16	35	tr.	4	2	1	tr.	tr.	1	0	170	—	—	—	0
Buttermilk	1 cup	245	90	90	9	tr.	—	—	—	13	298	0.1	10	0.09	0.44	0.2	2
Cabbage — raw	½ cup	45	92	10	1	tr.	—	—	—	2	22	0.2	60	0.02	0.02	0.2	42
— cooked	½ cup	85	94	18	1	tr.	—	—	—	3	32	0.2	95	0.03	0.03	0.2	24
Cabbage rolls	2	206	—	261	9	19	7	7	4	13	66	2.1	480	0.12	0.13	2.2	52

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids Saturated (Total)	Fatty Acids (Unsaturated) Oleic	Fatty Acids (Unsaturated) Lin-Oleic	Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Cakes																	
Angelfood	1 piece	53	34	135	3	—	—	—	—	32	50	0.2	0	tr.	0.06	0.1	0
Devil's Food	1 piece	69	24	235	3	9	3	4	1	40	41	0.6	100	0.02	0.06	0.2	0
White, without icing	1 piece	86	25	315	4	12	3	6	2	48	55	0.3	150	0.02	0.08	0.2	0
White, with icing	1 piece	114	23	400	4	12	3	6	2	71	56	0.3	150	0.02	0.08	0.2	0
Candy																	
Gum drops	1 oz.	28	12	100	tr.	tr.	—	—	—	25	2	0.1	0	0	tr.	tr.	0
Hard candy	1 oz.	28	1	110	0	tr.	—	—	—	28	6	0.5	0	0	0	0	0
Marshmallows	1 oz.	28	17	90	1	tr.	—	—	—	23	5	0.5	0	0	tr.	tr.	0
Milk chocolate bars:																	
All varieties	1¼ oz.	35	—	168	3	8	5	3	tr.	22	31	0.9	—	0.02	0.06	2.0	0
"Caravan," "Caramilk" type	1 oz.	28	8	116	1	4	2	2	tr.	20	36	0.4	10	0.02	0.05	tr.	tr.
"O Henry" type	1 oz.	28	7	129	3	6	2	3	1	16	36	0.3	tr.	0.07	0.04	1.0	tr.
Cantaloupe	¼	192	91	30	tr.	tr.	—	—	—	7	14	0.4	3270	0.04	0.06	0.6	32
Carrots — raw	1	50	88	20	1	tr.	—	—	—	5	18	0.4	5500	0.03	0.03	0.3	4
— cooked	½ cup	72	91	22	tr.	tr.	—	—	—	5	24	0.4	7610	0.04	0.04	0.4	4
Cashew nuts	¼ cup	35	5	196	6	16	3	11	1	10	14	1.4	35	0.15	0.09	0.6	—
Cauliflower	¾ cup	110	93	24	2	tr.	—	—	—	4	23	0.8	66	1.00	0.09	0.7	61
Celery	1 stock	40	94	5	tr.	tr.	—	—	—	2	16	0.1	100	0.01	0.01	0.1	4
Cereal — see Breakfast Cereals																	
Cheeseburger — with bun	1 burger	173	—	454	33	28	13	12	tr.	30	268	4.0	380	0.21	0.40	6.0	—
— meat only	1 patty	85	60	185	23	10	5	4	tr.	0	10	3.0	20	0.08	0.20	5.1	—
Cheeses																	
Blue	1 oz.	28	40	105	6	9	5	3	tr.	1	89	0.1	350	0.01	0.17	0.3	0
Camembert	1 oz.	28	52	84	5	5	3	2	tr.	1	29	0.1	280	0.01	0.21	0.2	0
Cheddar (1" cube=17 g)	1 oz.	28	37	116	7	8	5	3	tr.	tr.	211	0.3	360	tr.	0.13	tr.	0
Cheddar, processed	1 oz.	28	40	105	7	9	5	3	tr.	tr.	219	0.3	350	tr.	0.12	tr.	0
Cottage, creamed (4% fat)	½ cup	113	79	120	16	5	3	2	tr.	4	106	0.4	190	0.04	0.28	0.1	0
Cottage, not creamed	½ cup	100	79	85	17	tr.	2	tr.	tr.	3	90	0.4	10	0.03	0.28	0.1	0
Cream	1 oz./2 tbsp.	28	51	105	2	11	6	4	tr.	1	18	0.1	440	tr.	0.07	tr.	0
Swiss, processed, domestic	1 oz.	28	40	100	8	8	4	3	tr.	1	251	0.3	310	tr.	0.11	tr.	0
Swiss, processed, gruyere	1 oz.	28	40	115	8	9	5	3	tr.	1	308	0.3	560	0	0.14	0.1	0
Chelsea bun, Cinnamon Bun	1	50	31	158	3	5	—	—	—	26	27	0.9	210	0.08	0.09	0.8	0
Cherries — raw	½ cup	80	80	59	1	tr.	—	—	—	14	18	0.3	88	0.04	0.05	0.3	8
— canned	½ cup	128	78	104	1	tr.	—	—	—	26	19	0.4	77	0.02	0.02	0.2	4

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids			Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
							Saturated (Total)	(Unsaturated)									
								Oleic	Lin-Oleic								
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Chicken																	
Breast, fried (½ breast)																	
with bone	3.3 oz.	94	58	155	25	5	1	2	1	1	9	1.3	70	0.04	0.17	11.2	–
Meat only (1 c. diced=5⅓ oz.)	3 oz.	85	71	115	20	3	1	1	1	0	8	1.4	80	0.05	0.16	7.4	–
Chicken pot pie	1	227	63	535	23	31	10	15	3	42	68	3.0	3020	0.25	0.26	4.1	5
Chili con carne – with beans	½ cup	125	72	168	10	8	4	4	tr.	15	40	2.1	75	0.04	0.09	1.6	–
– without beans	½ cup	128	67	255	13	19	9	9	tr.	8	49	1.8	190	0.03	0.16	2.8	–
Chocolate bar – see Candy																	
Chop Suey	1 cup	155	–	180	16	10	–	–	–	8	36	2.9	360	0.17	0.23	3.0	20
Chow Mein	1 cup	155	–	158	19	6	–	–	–	6	36	1.6	170	0.05	0.14	2.6	6
Clams	3 oz.	85	86	45	7	1	–	–	–	2	47	3.5	–	0.01	0.09	0.9	–
Coconut	¼ cup	15	4	86	tr.	6	5	tr.	tr.	8	7	0.5	0	tr.	0.02	0.1	0
Coffee with cream and sugar	2 cups	–	–	86	2	6	4	2	tr.	10	30	tr.	260	tr.	0.04	tr.	tr.
Coleslaw	½ cup	100	83	99	1	8	–	–	–	7	43	0.4	150	0.05	0.05	0.3	29
Cookies																	
Brownies with nuts: (made from home recipe with enriched flour)	1	20	10	95	1	6	1	3	1	10	8	0.4	40	0.04	0.02	0.1	0
Chocolate chip: (made from home recipe with enriched flour)	1	10	3	50	1	3	1	1	1	6	4	0.2	10	0.01	0.01	0.1	0
Chocolate chip: commercial	1	10	3	50	1	2	1	1	tr.	7	4	0.2	10	tr.	tr.	tr.	0
Chocolate marshmallow	1	19	–	75	1	2	–	–	–	14	5	0.3	10	tr.	0.01	tr.	0
Fig bars, commercial	1	14	14	50	1	1	–	–	–	11	11	0.2	20	tr.	0.01	0.1	tr.
Sandwich, chocolate or vanilla, commercial	1	10	2	50	1	2	1	1	tr.	7	2	0.1	0	tr.	tr.	0.1	0
Social tea or arrowroot	1	5	2	20	tr.	1	tr.	tr.	tr.	4	–	–	–	–	–	–	0
Oatmeal, commercial	1	19	–	86	1	3	–	–	–	13	–	–	–	–	–	–	0
Corn – whole cob	1 ear	140	74	70	3	1	–	–	–	16	2	0.5	310	0.09	0.08	1.0	7
– kernels, cooked or canned	½ cup	83	79	70	2	tr.	–	–	–	16	4	0.4	290	0.02	0.04	0.7	4
Corn chips	1-1½ cups	28	–	160	2	10	–	–	–	16	–	–	–	–	–	–	–
Corned beef	3 oz.	85	59	185	22	10	5	4	tr.	0	17	3.7	20	0.01	0.20	2.9	–
Crab	3 oz.	85	77	85	15	2	–	–	–	1	38	0.7	–	0.07	0.07	1.6	–
Crackers																	
Graham, 2½″ square	4	28	6	110	2	3	–	–	–	21	11	0.4	0	0.01	0.06	0.4	0
Saltines, 2″ square	4	11	4	50	1	1	–	1	–	8	2	0.1	0	tr.	tr.	0.1	0
Rye wafers	4	28	6	96	4	tr.	–	–	–	21	15	1.1	0	0.09	0.07	0.3	0
Whole wheat	4	28	7	113	2	4	–	–	–	19	6	0.1	0	0.02	0.01	0.2	0

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids			Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
								(Unsaturated)									
							Saturated (Total)	Oleic	Lin-Oleic								
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Cream	1 tbsp.	15	72	30	1	3	2	1	tr.	1	15	tr.	130	tr.	0.02	tr.	tr.
Cucumbers	6 slices	50	96	5	tr.	tr.	—	—	—	2	8	0.2	tr.	0.02	0.02	0.1	6
Custard	½ cup	124	38	142	7	7	3	3	tr.	14	139	0.5	435	0.05	0.23	0.1	tr.
Danish pastry	1	65	22	275	5	15	5	7	3	30	33	0.6	200	0.05	0.10	0.5	0
Dates	1 oz.	28	22	77	1	tr.	—	—	—	20	16	0.8	14	0.02	0.03	0.6	0
Doughnuts	1	32	24	125	1	6	1	4	tr.	16	13	0.4	30	0.05	0.05	0.4	0
Duck — see Goose																	
Eclairs	1	110	—	315	8	15	—	—	—	39	90	1.3	730	0.12	0.24	1.0	0
Eggs																	
Boiled or poached	1	50	74	80	6	6	2	3	tr.	tr.	27	1.1	590	0.05	0.15	tr.	0
Scrambled	1	64	72	110	7	8	3	3	tr.	1	51	1.1	690	0.05	0.18	tr.	0
Fried	1	55	—	113	6	10	4	4	tr.	—	28	1.1	740	0.05	0.15	0	0
Eggplant	½ cup	100	19	19	1	0	0	0	0	0	11	0.6	10	0.05	0.04	0.5	3
Eggroll	1 medium	73	—	239	4	10	2	6	9	9	14	0.8	120	0.07	0.07	0.8	5
Farina (Wheatlets, Cream of Wheat) — see Breakfast Cereals																	
Figs	1 oz.	28	23	77	1	tr.	—	—	—	19	35	0.8	22	0.03	0.03	0.2	0
Fish — see also Salmon, Sardines and Tuna																	
Cod, fried in butter	4 oz.	95	65	162	26	5	2	1	tr.	—	29	0.9	170	0.08	0.10	2.8	—
Haddock, fried, breaded	3 oz.	85	66	140	17	5	1	3	tr.	5	34	1.0	—	0.03	0.06	2.7	2
Halibut, grilled with butter	3 oz.	85	67	146	21	6	—	—	—	0	14	0.7	580	0.04	0.06	7.1	—
Herring	1 herring	85	63	217	21	14	—	—	—	—	—	1.2	130	0.14	0.15	3.3	—
Lobster, canned	3 oz.	85	77	150	31	2	—	—	—	—	110	1.4	—	0.06	0.12	3.8	—
Mackerel, cooked	3 oz.	85	62	200	19	13	—	—	—	0	5	1.0	450	0.13	0.23	6.5	—
Ocean perch, breaded, fried	3 oz.	85	59	195	16	11	—	—	—	6	28	1.1	—	0.08	0.09	1.5	—
Sole — fillet, in butter	3 oz.	85	58	172	26	7	3	2	tr.	0	20	1.2	—	0.06	0.07	2.0	—
Frankfurters	1	56	57	170	7	15	—	—	—	1	3	0.8	—	0.08	0.11	1.4	—
French fries	10	57	45	155	2	7	2	2	4	20	9	0.7	tr.	0.07	0.04	1.8	12
Fruit cocktail	½ cup	128	80	98	tr.	tr.	—	—	—	25	12	0.5	180	0.02	0.02	0.6	2
Fruit drinks																	
Canned or bottled with added vitamin C. Individual fruit flavours or combinations of 2 or more	1 cup	250	90	135	tr.	tr.	—	—	—	35	12	0.5	130	0.05	0.02	0.2	40

							Fatty Acids										
								(Unsaturated)									
Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Saturated (Total)	Oleic	Lin-Oleic	Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Made with crystals with added vitamin C — orange, grapefruit, apple, etc. (Start, Tang, etc.)	1 cup	248	—	135	tr.	tr.	—	—	—	35	—	—	—	—	—	—	40
Fudge	1½ oz.	42	8	116	2	5	2	2	2	32	33	0.5	tr.	0.02	0.05	0.2	tr.
Gelatin desserts	¾ cup	90	84	60	2	0	—	—	—	14	—	—	—	—	—	—	—
Gin	1½ fl. oz.	42	—	105	—	—	—	—	—	—	—	—	—	—	—	—	—
Goose or Duck, cooked	3 oz.	85	55	198	29	8	—	—	—	0	12	1.4	—	0.09	0.14	7.9	—
Grapefruit	½	241	89	45	1	tr.	—	—	—	12	19	0.5	10	0.05	0.02	0.2	44
Grapefruit juice	½ cup	123	90	48	tr.	tr.	—	—	—	12	11	0.2	10	0.04	0.02	0.2	46
Grapes	½ cup	76	82	32	tr.	tr.	—	—	—	8	8	0.2	50	0.02	0.02	0.1	2
Grape juice	½ cup	126	83	82	tr.	tr.	—	—	—	21	14	0.4	—	0.05	0.02	0.2	20
Ham	3 oz.	85	54	245	18	19	7	8	2	0	8	2.2	0	0.40	0.16	3.1	—
Hamburger — with bun	1 burger	145	—	409	26	19	8	9	tr.	30	49	3.7	30	0.21	0.28	6.0	—
— meat only	1 patty	85	60	185	23	10	5	4	tr.	0	10	3.0	20	0.08	0.20	5.1	—
Heart, beef	2 oz.	57	41	107	18	3	—	—	—	1	3	3.0	13	0.14	0.07	4.4	1
Honey	2 tbsp.	42	34	130	tr.	0	—	—	—	34	2	0.2	0	tr.	0.02	0.2	tr.
Ice cream	¾ cup	100	63	191	4	10	6	4	tr.	21	146	0.1	442	0.04	0.21	0.1	1
Ice cream sundae	1 cup	204	—	569	10	32	12	10	6	65	268	1.5	582	0.14	0.39	0.7	1
Jam and preserves	2 tbsp.	40	58	110	tr.	tr.	—	—	—	28	8	0.4	tr.	tr.	0.02	tr.	tr.
Jellies	2 tbsp.	36	58	110	tr.	tr.	—	—	—	26	8	0.6	tr.	tr.	0.02	tr.	1
Kale, cooked	½ cup	90	91	25	3	1	—	—	—	4	121	1.1	6660	0.19	0.16	1.4	56
Kidneys — beef	2 oz.	57	53	103	11	6	—	—	—	1	7	5.8	756	0.11	1.21	2.3	0
— pork	2 oz.	57	55	65	9	3	—	—	—	1	6	4.6	74	0.33	0.97	5.6	7
Lamb, chop	1, bone in	137	47	400	25	33	18	12	1	0	10	1.5	—	0.14	0.25	5.6	—
	1, no bone	112	47	400	25	33	18	12	1	0	10	1.5	—	0.14	0.25	5.6	—
Lamb, leg roast	3 oz.	85	54	235	22	16	9	6	tr.	0	9	1.4	—	0.13	0.23	4.7	—
Lasagna** — with meat	1 cup	384	—	538	38	30	11	9	1	32	514	3.1	1980	0.13	0.52	3.6	20
— without meat	½ cup	170	—	208	14	11	4	3	1	16	255	0.9	983	0.05	0.22	0.7	10
Lentils, cooked	½ cup	75	69	80	6	tr.	—	—	—	15	19	1.6	15	0.06	0.05	0.5	0
Lettuce, leaves	2 large	50	94	10	1	tr.	—	—	—	2	34	0.7	950	0.03	0.04	0.2	9

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids			Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
							Saturated (Total)	(Unsaturated) Oleic	(Unsaturated) Lin-Oleic								
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Lima beans – see Beans																	
Liver																	
Beef liver, fried	2 oz.	57	57	130	15	6	–	–	–	3	6	5.0	30280	0.15	2.37	9.4	15
Calves' liver, fried (2½" x 2¼" x ⅜")	2 slices	58	52	118	13	6	–	–	–	2	4	7.2	15300	0.10	1.90	9.4	21
Chicken liver, fried	2 livers	60	65	148	18	7	–	–	–	2	–	6.0	25760	0.11	1.77	9.4	8
Pork liver, fried (2½" x 2¼" x ⅜")	2 slices	59	54	136	14	6	–	–	–	6	8	12.5	9660	0.20	1.84	9.9	8
Lobster – see Fish																	
Lunch meats																	
Bologna – see Bologna																	
Salami – see Salami																	
Canned lunch meat	1 oz.	29	55	83	4	7	3	3	1	1	3	0.6	0	0.09	0.06	0.8	–
Macaroni, cooked	½ cup	70	72	78	3	1	–	–	–	16	6	0.3	0	0.01	0.01	0.2	0
Macaroni and cheese	1 cup	220	58	430	18	24	11	10	1	44	398	2.0	950	0.22	0.44	2.0	tr.
Mayonnaise	1 tbsp.	14	15	100	tr.	11	2	2	6	tr.	3	0.1	40	tr.	0.01	tr.	0
Milk																	
Whole, 3.5% fat	1 cup	244	87	160	9	9	5	3	tr.	12	288	0.1	350	0.07	0.41	0.2	2
Non fat (skim)	1 cup	245	90	90	9	tr.	–	–	–	13	298	0.1	10	0.10	0.44	0.2	2
Partially skimmed, 2% fat	1 cup	245	87	123	9	5	3	2	tr.	12	294	0.1	172	0.10	0.44	0.2	2
Milkshake	1 cup	270	83	280	13	12	–	–	–	32	364	0.8	670	0.17	0.56	0.2	2
Mixed vegetables	½ cup	80	83	51	2	tr.	–	–	–	11	20	1.0	3960	0.10	0.06	0.9	6
Molasses – light (first extraction)	1 tbsp.	20	24	50	–	–	–	–	–	13	33	0.9	–	0.01	0.01	tr.	–
– blackstrap	1 tbsp.	20	24	45	–	–	–	–	–	11	137	3.2	–	0.02	0.04	0.4	–
Muffins – bran	1	35	–	86	3	3	tr.	2	tr.	14	35	1.3	60	0.07	0.09	1.5	0
– plain	1	40	38	120	3	4	1	2	1	17	42	0.6	40	0.07	0.09	0.6	tr.
– cornmeal	1	40	33	125	3	4	1	2	1	20	96	0.6	100	0.07	0.08	0.6	0
Mushrooms, fresh, sauteed	4 average	70	93	78	2	7	3	2	tr.	3	8	0.7	170	0.05	0.28	2.9	tr.
Nectarines	1 medium	150	82	96	1	tr.	–	–	–	26	6	0.8	2475	–	–	–	20
Noodles	½ cup	80	70	100	4	1	1	1	tr.	19	8	0.5	55	0.03	0.02	0.3	0
Nuts – see individual varieties by name, peanuts, etc.																	
Onions – raw	1	110	89	40	2	tr.	–	–	–	10	30	0.6	40	0.04	0.04	0.2	11
– cooked	½ cup	105	92	30	2	tr.	–	–	–	7	25	0.4	40	0.03	0.03	0.2	7

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids			Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
							Saturated (Total)	(Unsaturated) Oleic	(Unsaturated) Lin-Oleic								
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Onions, French fried – see French fries																	
Oranges	1	180	86	65	1	tr.	–	–	–	16	54	0.5	260	0.13	0.05	0.5	66
Orange juice	½ cup	124	88	55	1	tr.	–	–	–	13	14	0.2	250	0.11	0.04	0.5	62
Oysters	3 oz.	85	82	65	7	2	–	–	–	4	24	4.8	–	0.02	0.17	0.7	–
Pancakes, plain	1 (6″ diam.)	40	50	90	3	3	2	2	tr.	9	87	0.4	105	0.06	0.09	0.3	–
with butter and syrup	1 (6″ diam.)	96	–	310	3	15	8	6	tr.	39	108	2.0	575	0.06	0.09	0.3	–
Parsley	½ cup	32	85	tr.	tr.	tr.	–	–	–	tr.	64	1.6	2720	tr.	0.08	tr.	56
Parsnips, cooked	⅓ cup	78	82	50	1	tr.	–	–	–	12	35	0.4	25	0.06	0.06	0.1	8
Peaches, raw	1	114	89	35	1	tr.	–	–	–	10	9	0.5	1320	0.02	0.05	1.0	7
canned	½ cup	128	79	100	tr.	tr.	–	–	–	26	5	0.4	550	0.01	0.03	0.7	4
Peanuts	¼ cup	36	2	210	9	18	4	8	5	7	27	0.8	–	0.12	0.05	6.2	0
Peanut butter	2 tbsp.	32	2	190	8	16	4	8	4	6	18	0.6	–	0.04	0.04	4.8	0
Pears, raw	1	182	83	100	1	1	–	–	–	25	13	0.5	30	0.04	0.07	0.2	7
canned	½ cup	128	80	98	tr.	tr.	–	–	–	25	6	0.2	tr.	0.02	0.02	0.2	2
Peas, cooked	½ cup	80	82	58	4	tr.	–	–	–	10	18	1.4	430	0.22	0.08	1.8	16
dried, cooked	½ cup	125	70	145	10	1	–	–	–	26	14	2.1	50	0.19	0.11	1.1	0
Peppers, raw	1 pod	74	93	15	1	tr.	–	–	–	4	7	0.5	310	0.06	0.06	0.4	94
cooked	1 pod	73	95	15	1	tr.	–	–	–	3	7	0.4	310	0.05	0.05	0.4	70
Pies, apple	1 sector	160	–	410	3	18	5	11	1	61	1	0.5	50	0.03	0.03	0.6	2
cherry	1 sector	160	–	387	4	18	5	11	1	62	22	0.5	710	0.03	0.03	0.8	tr.
custard	1 sector	150	–	327	9	17	6	10	1	35	144	0.9	350	0.08	0.24	0.4	0
lemon meringue	1 sector	140	–	357	5	14	5	8	1	53	20	0.7	240	0.05	0.11	0.3	4
Pineapple, raw	½ cup	70	85	38	tr.	tr.	–	–	–	10	12	0.4	50	0.02	0.02	0.2	12
cooked or canned	½ cup	130	80	98	tr.	tr.	–	–	–	25	15	0.4	60	0.10	0.03	0.2	8
Pizza, cheese only	1-5½″ sector	75	45	185	7	6	2	3	tr.	27	107	0.7	290	0.04	0.12	0.7	4
sausage and cheese	1-5½″ sector	105	45	315	14	17	2	3	tr.	27	111	1.8	290	0.12	0.18	1.6	4
Plums, raw	1	60	87	25	tr.	tr.	–	–	–	7	7	0.3	140	0.02	0.02	0.3	3
canned	½ cup	128	77	102	tr.	tr.	–	–	–	26	11	1.1	1485	0.02	0.02	0.4	2
Popcorn, plain	2 cups	18	6	80	2	4	2	tr.	tr.	10	2	0.4	–	–	0.02	0.2	0
butter and salt	2 cups	28	–	150	2	12	6	2	tr.	10	4	0.4	340	–	0.02	0.2	0
Popsicle	1	95	80	70	1	tr.	–	–	–	17	tr.	tr.	0	tr.	tr.	tr.	–
Pork, chop	1	98	42	260	16	21	8	9	2	0	8	2.2	0	0.63	0.18	3.8	–
roast	3 oz.	85	46	310	21	24	9	10	2	0	9	2.7	0	0.78	0.22	4.7	–
Potatoes, boiled	1	122	83	80	2	tr.	–	–	–	18	7	0.6	tr.	0.11	0.04	1.4	20
baked	1	99	75	90	3	tr.	–	–	–	21	9	0.7	tr.	0.10	0.04	1.7	20

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids			Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
							Saturated (Total)	(Unsaturated)									
								Oleic	Lin-Oleic								
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
mashed	½ cup	98	80	93	2	4	2	2	tr.	12	24	0.4	165	0.08	0.05	1.0	9
Potato chips	1 cup	40	2	230	2	16	4	4	8	20	16	0.8	tr.	0.08	0.02	2.0	6
Prunes	4	32	28	70	1	tr.	–	–	–	18	14	1.1	440	0.02	0.04	0.4	1
Pudding, instant	½ cup	157	–	182	6	5	3	2	tr.	32	150	0.5	180	0.05	0.23	0.1	1
rice	½ cup	97	–	141	3	3	–	–	–	26	95	0.4	110	0.03	0.13	0.2	tr.
tapioca	½ cup	105	–	133	5	5	–	–	–	17	105	0.5	310	0.05	0.19	0.1	1
Radishes	4	40	94	5	tr.	tr.	–	–	–	1	12	0.4	tr.	0.01	0.01	0.1	10
Raisins	1 oz.	28	18	80	tr.	tr.	–	–	–	22	18	1.0	tr.	0.04	0.02	0.2	tr.
Raspberries	¾ cup	92	84	52	tr.	tr.	–	–	–	13	20	0.8	120	0.03	0.08	0.8	23
Rhubarb, cooked	½ cup	136	63	192	tr.	tr.	–	–	–	49	106	0.8	110	0.03	0.08	0.4	8
Rice, regular or instant	½ cup	80	73	92	2	tr.	–	–	–	20	16	0.7	0	0.10	0.01	1.0	0
brown, parboiled or converted	½ cup	80	71	99	2	tr.	–	–	–	21	9	0.4	0	0.10	0.01	1.3	0
Rolls and Buns																	
White dinner roll	1	30	40	90	2	2	–	–	–	16	18	0.4	0	0.08	0.04	0.8	0
Hamburg or hot dog bun	1	60	31	164	5	2	tr.	1	tr.	30	40	1.0	0	0.14	0.10	1.4	0
Whole wheat roll	1	30	40	79	3	2	–	–	–	16	13	0.5	0	0.06	0.02	0.9	0
Rye whiskey	1½ fl. oz.	42	–	105	–	–	–	–	–	–	–	–	–	–	–	–	–
Rye Krisp crackers – see Crackers																	
Salami, dry	1 oz.	28	30	130	7	11	–	–	–	tr.	4	1.0	–	0.10	0.07	1.5	–
cooked	1 oz.	28	51	90	5	7	–	–	–	tr.	3	0.7	–	0.07	0.07	1.2	–
Salmon, canned	3 oz.	85	71	120	17	5	1	1	tr.	0	167	0.7	60	0.03	0.16	6.8	–
fresh, fried	3 oz.	85	71	155	23	6	1	1	tr.	0	–	1.0	140	0.14	0.05	6.2	–
Sardines	3 oz.	85	62	175	20	9	–	–	–	0	372	2.5	190	0.02	0.17	4.6	–
Sausages	3 links	39	35	188	8	16	6	8	2	tr.	3	0.9	0	0.32	0.14	1.5	–
Shrimp	⅔ cup	85	70	100	21	1	–	–	–	1	98	2.6	50	0.01	0.03	1.5	–
Soda crackers – see Crackers																	
Soft drinks, cola	10 fl. oz.	308	90	121	0	0	–	–	–	31	–	–	0	0	0	0	0
ginger ale	10 fl. oz.	305	92	95	0	0	–	–	–	24	–	–	0	0	0	0	0
Soups, made with milk only																	
Cream of chicken	¾ cup	138	85	101	4	8	2	2	3	9	107	0.3	141	0.03	0.17	0.4	1
Cream of mushroom	¾ cup	138	83	121	4	6	2	2	2	8	97	0.3	344	0.03	0.15	0.4	2
Cream of tomato	¾ cup	141	84	98	4	4	2	2	1	13	95	0.5	675	0.06	0.14	0.8	8
Spaghetti, cooked	½ cup	70	72	78	3	1	–	–	–	16	6	0.3	0	0.01	0.01	0.2	0

							Fatty Acids										
								(Unsaturated)									
Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Saturated (Total)	Oleic	Lin-Oleic	Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Spaghetti and meat sauce	1 cup	248	70	330	19	12	4	6	1	39	125	3.8	1600	0.26	0.30	4.0	22
Spaghetti and tomato sauce	½ cup	125	80	145	3	1	1	1	1	19	20	1.4	465	0.18	0.14	2.3	5
Spinach	½ cup	90	92	20	2	tr.	–	–	–	3	84	2.0	7290	0.06	0.12	0.5	25
Squash, summer	½ cup	105	96	15	1	tr.	–	–	–	4	26	0.4	410	0.05	0.08	0.8	10
winter	½ cup	102	81	65	2	tr.	–	–	–	16	28	0.8	4305	0.05	0.14	0.7	14
Strawberries	¾ cup	112	90	41	tr.	tr.	–	–	–	10	23	1.1	68	0.03	0.08	0.8	66
Sugar	1 tbsp.	11	tr.	40	0	0	–	–	–	11	0	tr.	0	0	0	0	0
Sundae – see Ice cream sundae																	
Sweet potatoes	1	110	64	155	2	1	–	–	–	36	44	1.0	8910	0.10	0.07	0.7	24
Syrups, table blend	1 tbsp.	21	24	60	0	0	–	–	–	15	9	0.8	0	0	0	0	0
maple	1 tbsp.	21	–	50	0	0	–	–	–	13	33	0.6	0	0	0	0	0
Tangerines	1	116	87	40	1	tr.	–	–	–	10	34	0.3	360	0.05	0.02	0.1	27
Tangerine juice	½ cup	124	88	58	tr.	tr.	–	–	–	14	22	0.2	510	0.07	0.02	0.2	34
Tapioca pudding – see Pudding																	
Tea with cream and sugar	2 cups	–	–	86	2	6	4	2	tr.	10	30	tr.	260	tr.	0.04	tr.	tr.
Tomatoes, raw	1 medium	150	94	35	2	tr.	–	–	–	7	20	0.8	1350	0.10	0.06	1.0	34
canned	¾ cup	181	94	38	2	tr.	–	–	–	8	10	0.9	1628	0.09	0.05	1.3	31
juice	¾ cup	182	94	34	2	tr.	–	–	–	8	13	1.6	1455	0.10	0.05	1.4	29
Tongue	1 oz.	28	61	69	6	5	–	–	–	tr.	2	0.6	–	0.01	0.08	1.0	–
Triscuits, whole wheat crackers – see Crackers																	
Tuna	3 oz.	85	61	170	24	7	2	1	1	0	7	1.6	70	0.04	0.10	10.1	–
Turkey	3 oz.	85	56	160	25	6	–	–	–	0	24	5.0	10	0.06	0.14	5.8	0
Turkey pot pie – see Chicken pot pie																	
Turnips	½ cup	100	91	35	1	tr.	–	–	–	8	59	tr.	550	0.06	0.06	0.5	26
Turnover, any fruit flavour	1	160	–	410	3	18	5	11	1	61	1	0.5	50	0.03	0.03	0.6	2
Veal, cutlet	3 oz.	85	60	185	23	9	5	4	tr.	–	9	2.7	–	0.06	0.21	4.6	–
roast	3 oz.	85	55	230	23	14	7	6	tr.	0	10	2.9	–	0.11	0.26	6.6	–
Vodka	1½ fl. oz.	42	–	105	–	–	–	–	–	–	–	–	–	–	–	–	–
Waffles, plain	1 (6″ diam.)	64	41	180	6	6	2	3	1	24	73	1.1	214	0.11	0.16	0.8	0
with butter and syrup	1 (6″ diam.)	120	–	400	6	18	8	7	1	54	94	2.7	684	0.11	0.16	0.8	0
Walnuts	¼ cup	25	4	162	4	16	1	2	10	4	25	0.8	8	0.08	0.03	0.2	–
Watermelon	1 wedge	925	93	115	2	1	–	–	–	27	30	2.1	2510	0.13	0.13	0.7	30
Weiners – see Frankfurters																	

Food Item	Measure	Weight	Moisture	Food Energy	Protein	Fat	Fatty Acids Saturated (Total)	Fatty Acids (Unsaturated) Oleic	Fatty Acids (Unsaturated) Lin-Oleic	Carbohydrate	Calcium	Iron	Vitamin A Value	Thiamin	Riboflavin	Niacin	Ascorbic Acid
		g	%	cal	g	g	g	g	g	g	mg	mg	I.U.	mg	mg	mg	mg
Wheat bran	3 tbsp.	25	12	53	4	1	–	–	–	15	30	3.7	–	0.18	0.09	5.0	–
Wheat germ	3 tbsp.	25	12	90	7	3	1	–	2	12	18	2.6	–	0.50	0.17	1.1	–
Wine, dessert	6 fl. oz.	171	–	233	–	–	–	–	–	14	14	–	–	0.02	0.04	0.4	–
table	6 fl. oz.	171	–	145	–	–	–	–	–	7	15	–	–	tr.	0.02	0.2	–
Yogurt, made from partially skimmed milk, plain	6 oz.	185	89	112	9	3	2	1	tr.	13	310	0.1	130	0.08	0.45	0.2	2
made from partially skimmed milk, fruit flavoured (average)	6 oz.	185	89	170	8	3	2	1	tr.	30	230	0.1	100	0.07	0.32	0.2	2

Sources:

*Manufacturer's data

**Calculated from recipe

Sources:

1. Department of National Health and Welfare, Nutrient Value of Some Common Foods (Ottawa: Department of National Health and Welfare, 1971).
2. B. K. Watt and A. L. Merrill, Composition of Foods, Agriculture Handbook No. 8 (Washington, D.C.: U.S. Department of Agriculture, 1963).

Errata

Part 2, p.2, column 2, table 2.1, under "Bath 1" – temperature should read "$T_1 = \_\_\_\_{}^\circ C$", not "$T_1 = 2^\circ C$".

Part 3, p.25, column 2, under "An Important Activity" line 4, reference should read "table 3.9 and figure 3.9", not "table 3.7 and 3.8".

Part 3, p.38, column 1, at first asterisk, text should read "Refer to figure 3.14 . . .", not "Refer to table 3.14 . . .".

Part 3, p.38, column 2, last entry, bottom line, should read ". . . may be found on p.52", not ". . . may be found on p. 38".

Part 3, p.40, column 1, first paragraph under "calculating costs", line 3, should read ". . . in figure 3.14", not ". . . in figure 3.15".

Part 3, p.42, heading "Using the Steam Turbine . . .", should read "(Figures 3.18 to 3.21)", not "(Figures 3.18 to 3.23)".

Part 4, p.14, column 1, Drawcard back for making a hot drink should read "Advance", not "Go Back".

Part 4, p.23, column 1, 2nd paragraph, line 5, should read "p.18 and table 4.4", not "p.21 and table 4.5".

Part 4, p.31, column 1, 2nd last entry, should read "electricity is 32% efficient; multiply energy by 3.12", not "electricity is 100% efficient; multiply energy by 1.00".